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INSTRUCTION MANUAL
MODEL 501~~A~~

VCF/SWEEP
FUNCTION GENERATOR

Serial No. 24631
Upw 700203

Received Nov 5-1-81

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EXACT electronics, inc.

IF YOUR INSTRUMENT DOES NOT OPERATE

PLEASE

1. Check operating procedure in manual for proper setup.

2. Check fuse and power supply voltages.

3. Call your Exact representative or factory. Instruments returned to the factory will be accepted only if they are sent freight prepaid, unless Exact or factory representative has authorized otherwise.

CLAIM FOR DAMAGED SHIPMENT

The instrument should be inspected as soon as received. If damage has occurred, a claim should be made with the carrier. The claim agent should receive a complete report of damage and a copy sent to Exact. After receiving this report, Exact will advise you of the dispostion of the instrument and arrange for its repair or replacement.

WARRANTY

Exact warrants its instruments to be free from defects in material and workmanship under normal use for a period of twelve months from the original date of shipment. Exact's obligation is limited to repair or replacement.

All repairs and replacements made under this warranty are f.o.b. Exact's factory or designated service depot unless otherwise authorized by Exact. This warranty is made on condition that prompt notice of defect is given to Exact, in writing, within the warranty period and that Exact shall have the sole right to determine whether in fact a defect exists.

This warranty does not apply to any instrument which has been repaired or altered by other than Exact's own service representative so as, in Exact's judgment, to adversely affect it, nor which has been subject to misuse, negligence or accident or which has been operated contrary to sound practice or operating instructions.

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INTRODUCTION

The Exact Electronic Model 501 Function Generator is a commercially designed instrument utilizing state-of-the-art electronics technology. It is designed to provide maximum versatility with proven design.

Any one of seven selectable waveforms is available at a 50Ω output. The maximum output is 30 Volts Peak to Peak open circuit (or 15 Volts Peak). The frequency range of the instrument is from 1Hz to 5MHz, with seven selectable ranges. Each range is continuously adjustable over three decades through the use of a Kelvin-Varley divider.

Internal sweeping capabilities are included to provide up to three decades of sweep on any of the seven frequency ranges. Sweep times are continuously adjustable from 10msec to over 100 seconds.

Additional features are gate and trigger mode operations, DC offsetting the output, and varying the symmetry of the waveform selected.

This manual is designed to help the operator familiarize himself with the instrument. Functional block diagram and circuit descriptions are an aid to troubleshooting. Calibration procedures, operation check, and specification check procedures are provided as well.

The new operator should look first to the First Time Operation Procedures. As operators become more familiar with the instrument, they will find the Operating Procedures more helpful.

SECTION 1

SPECIFICATIONS

1.1.0 INSTRUMENT SPECIFICATIONS

MAIN GENERATOR

WAVEFORMS
Sine, triangle, square, pos pulse, neg pulse, pos ramp, neg ramp, sync.

MODES OF OPERATION
Run, gate, trigger, sweep.

DYNAMIC FREQUENCY RANGE
0.1 Hz to 5 MHz.

FREQUENCY ACCURACY
± (1% of setting + 1% of full scale) 0.1 Hz to 1 MHz.
± (2% of setting + 2% of full scale) 1 MHz to 5 MHz.

MAIN OUTPUT
50 Ohm output impedance.
30 V P-P into an open circuit.
15 V P-P into 50 Ohms.
Ramp:
15 V peak into an open circuit.
7.5 V peak into 50 Ohms.

ATTENUATOR
60 dB in 10 dB steps plus 20 dB continuously variable (80 dB total).

VARIABLE DC OFFSET
+15 V to -15 V open circuit.
+7.5 V to -7.5 V into 50 Ohms.
Note: Protection circuit will automatically clip waveform if DC offset plus signal exceed maximum voltage.

SQUAREWAVE
Rise and fall times: <50nsec.
Overshoot and ringing: <5% of maximum P-P amplitude.

SYMMETRY (TIME)
± (1% + 10 nsec). Variable symmetry off.

SINE DISTORTION
<0.5% to 100 kHz.
No harmonics <30dB down 100 kHz to 5 MHz.

SINE FREQUENCY RESPONSE
< ±0.1 dB to 100 kHz.
< ± 1 dB 100 kHz to 5 MHz.

TRIANGLE NON-LINEARITY

<1% (Best straight line method) 0.1 Hz to 100 kHz.

MAIN SYNC OUTPUT

Squarewave, approximately 5 V Peak. TTL compatible.

VCF INPUT (Voltage controlled frequency)

Approx. 5 V input for 1000:1 (3 decades) frequency control.

FREQUENCY STABILITY

0.05% of setting for 10 min.
0.25% of setting for 24 hrs.

AMPLITUDE STABILITY

0.05% of setting for 10 min.
0.25% of setting for 24 hrs.

SYMMETRY CONTROL

Continuously variable from 19:1 to 1:19.
The generator frequency is divided by approximately 10 when operating in this mode.

GATE AND TRIGGER

Requirements: Manual pushbutton depression or external voltage at TRIG input.
Minimum trigger level; 250 mV P-P.

RAMP GENERATOR

RAMP TIME

10 msec to 100 sec.

SWEEP OUTPUT

-2 Volts Peak into 50 Ohms.

RAMP SYNC OUTPUT

2 V Peak open circuit.
Ramp sync is a positive pulse during ramp retrace.

POWER REQUIREMENTS

117 VAC ± 10% (Other voltages available).
50 Hz to 400 Hz
Approximately 30 watts.

PHYSICAL CHARACTERISTICS

31.8 cm wide x 12.7 cm high x 27.9 cm deep. Weight approximately 4.5 kg.

NOTE: Unless otherwise specified, specifications apply between 10% and 100% of maximum output voltage terminated into 50 Ohms and do not apply in the Search (S) mode. Specifications are valid at 25° C ± 5° C at constant line voltage after a 30 minute warm-up. Specifications subject to change without notice.

1.2.0 SPECIFICATION CHECK PROCEDURE

A. Equipment Required:

Counter/Timer: 5.5 MHz to 10,000 seconds
DANA 8010B or equivalent

Oscilloscope: DC to 100 MHz
5 mv/cm with differential comparator
Tektronix 7704 with 7A13 plug-in or equivalent

Harmonic Distortion Analyzer: less than .1% residual distortion
Hewlett Packard 334 or equivalent

Spectrum Analyzer: 100 KHz to 100 MHz
Hewlett Packard 141T, 8552B, 8553B or equivalent

B. Procedure:

FREQUENCY ACCURACY

1. Set the front panel controls as follows:

POWER	ON
RANGE-Hz	1K
START LEVEL	MID RANGE
MULTIPLIER/START FREQ	1.0-00
MAIN MODE	RUN
VAR SYMMETRY	FULLY CW
FUNCTION	SINE
AMPLITUDE	FULLY CW
STOP FREQ	.0-00
RAMP TIME	100msec.
VARIABLE	CAL
DC OFFSET	OFF
ATTENUATORS	ALL OFF
VAR SYM	OFF

2. Apply power to the instrument and connect a frequency counter to the SYNC OUT connector.

3. Observe time interval on counter of 1000 µsec ± 20 µsec.

4. Set RANGE to 100. Observe time interval of 10msec ± 0.2msec.

5. Set RANGE to 10. Observe time interval of 100msec ± 2msec.

6. Set RANGE to 1. Observe time interval of 1000msec ± 20msec.

1.2.0 SPECIFICATION CHECK PROCEDURE (Cont.)

7. Set MULTIPLIER/START FREQ to 0.1-00. Observe time interval of 10,000msec ± 1100msec.

8. Set RANGE to 10. Observe time interval of 1000msec ± 110msec.

9. Set RANGE to 100. Observe time interval of 100msec ± 11msec.

10. Set RANGE to 1K. Observe time interval of 10msec ± 1.1msec.

11. Set RANGE to 10K. Observe frequency of 1KHz ± 110Hz.

12. Set RANGE to 100K. Observe frequency of 10KHz ± 1.1KHz.

13. Set RANGE to 1M. Observe frequency of 100KHz ± 11KHz.

14. Set RANGE to 5M. Observe frequency of 500KHz ± 110KHz.

15. Set MULTIPLIER/START FREQ to 1.0-00. Observe frequency of 5MHz ± 200KHz.

16. Set RANGE to 1M. Observe frequency of 1MHz ± 20KHz.

17. Set RANGE to 100K. Observe frequency of 100KHz ± 2KHz.

18. Set RANGE to 10K. Observe frequency of 10KHz ± 200Hz.

TIME SYMMETRY

1. Activate the VAR SYM toggle. Measure time interval, A to B; A channel triggered on negative slope. Observe a time interval of $<50\mu$ sec.

2. Rotate VAR SYMMETRY maximum CCW. Observe time interval of $>950\mu$sec.

3. Deactivate the SYM toggle. Measure time interval, A to B, then B to A. Observe difference < 2msec.

RAMP GENERATOR

1. Connect counter/timer to RAMP SYNC. Measure time interval B to A. Observe time interval of approximately 100msec.

2. Rotate the variable control to X10. Observe time interval of > 1sec.

3. Set SWEEP TIME to 1sec. Observe time interval of >10sec.

4. Rotate the variable control to CAL. Observe time interval of approximately 1 sec.

1.2.0 SPECIFICATION CHECK PROCEDURE (Cont.)

5. Set SWEEP TIME to 10sec. Observe time interval of approximately 10 sec.

6. Set SWEEP TIME to 10msec. Observe time interval of approximately 10 msec.

SYNC OUTPUT AMPLITUDE

1. Connect SYNC OUT to the oscilloscope with 50Ω coaxial cable and 50Ω feed-through termination. Measure the Peak-to-Peak amplitude. Observe >2V P-P.

SWEEP OUTPUT AMPLITUDE

1. Connect SWEEP OUT to the oscilloscope with a 50Ω feed-through termination. Observe a sweep ramp peak of -2V + OmV -500mV.

MAIN OUTPUT

1. Connect MAIN OUT 50Ω to the oscilloscope with 50Ω termination. Observe a >15V P-P sine wave.

2. Select triangle and square waveforms and observe >15V P-P on each waveform.

3. Select positive pulse and negative pulse waveforms and observe >7.5V Peak and >-7.5V Peak respectively for each waveform.

4. Select positive ramp and negative ramp waveforms and observe >+7.5V Peak and >-7.5V Peak respectively for each waveform.

GATE AND TRIGGER MODES

1. Set:

MAIN MODE	GATE
FUNCTION	SINE

2. Observe DC level present at MAIN OUT 50Ω.

3. Adjust START LEVEL through its range and observe a corresponding shift in the DC level at MAIN OUT. Also observe that the generator will free-run when START LEVEL approaches the CW limit.

4. Center the START LEVEL control. Observe that a sine wave is gated to MAIN OUT whenever the MANual toggle is activated.

5. Select TRIG on MAIN MODE. Observe that a single sine wave is gated to the output each time MANual is activated.

1.2.0 SPECIFICATION CHECK PROCEDURE (Cont.)

SINE WAVE DISTORTION

1. Set MAIN MODE to RUN. Connect a distortion analyzer to the MAIN OUT 50Ω. Observe sine distortion of <.5%.

2. Set RANGE -Hz to 5Mz. Connect the spectrum analyzer to MAIN OUTPUT and observe harmonics >30dB down.

ATTENUATORS

1. Set RANGE -Hz to 10K. Reconnect distortion analyzer to MAIN OUTPUT.

2. Set the distortion analyzer to voltmeter and + 20dB range. Adjust AMPLITUDE for 0dB on the analyzer.

3. Activate 10dB ATTENUATOR. Set distortion analyzer to + 10dB. Observe 0dB ± .2dB.

4. Activate 20dB and deactivate 10dB ATTENUATORS. Set distortion analyzer to 0dB. Observe 0dB ± .2dB.

5. Activate 10dB ATTENUATOR. Set distortion analyzer to -10dB. Observe 0dB ± .4dB.

6. Activate 30dB and deactivate 10dB and 20dB ATTENUATORS. Observe 0dB ± .2dB.

7. Activate 10dB ATTENUATOR. Set distortion analyzer to -20dB. Observe 0dB ± .4dB.

8. Activate 20dB and deactivate 10dB ATTENUATORS. Set distortion analyzer to -30dB. Observe 0dB ± .4dB.

9. Activate 10dB ATTENUATOR. Set distortion analyzer to -40dB. Observe 0dB ± .6dB.

10. Disconnect distortion analyzer. Connect output to oscilloscope and terminate in 50Ω. Deactivate all ATTENUATORS. Set AMPLITUDE to maximum CCW.

11. Observe output amplitude of <1.5V P-P.

FREQUENCY RESPONSE

1. Set RANGE to 100K and AMPLITUDE to maximum CW.

1.2.0 SPECIFICATION CHECK PROCEDURE (Cont.)

2. Select MAIN MODE SWEEP. Measure the maximum and minimum P-P amplitudes of the sine wave during sweep. Observe <±.1dB (1.2%) variation.

3. Select RANGE-Hz 5M. Observe <± 1dB (12%) P-P amplitude variation.

RISE AND FALL TIMES

1. Set MAIN MODE to RUN, and FUNCTION to SQUARE.

2. Observe rise and fall times of <50nsec.

3. Select positive pulse. Observe rise and fall times of <50nsec.

4. Select negative pulse. Observe rise and fall times of <50nsec.

DC OFFSET

1. Connect oscilloscope unterminated to MAIN OUT 50Ω. Set FUNCTION to SQUARE, and RANGE to 1K.

2. Set MAIN MODE to GATE and adjust START LEVEL for an output of 0V ± .1V.

3. Activate DC OFFSET. Rotate DC OFFSET and observe DC level shift of >±15V.

TRIANGLE LINEARITY

1. Set DC OFFSET to OFF, FUNCTION to TRIANGLE, MAIN MODE to RUN.

2. Adjust oscilloscope to obtain 1/2 cycle of triangle across full horizontal grid of CRT.

3. Set vertical sensitivity to 1.0V/cm.

4. Adjust comparison voltage until negative peak is on horizontal center line. Record the reference voltage.

5. Adjust the comparison voltage until slope of triangle intersects second major mark at the horizontal center line.

6. Record the new reference voltage.

7. Adjust the comparison voltage until the slope of the triangle intersects the next major vertical mark at the horizontal center line.

1.2.0 SPECIFICATION CHECK PROCEDURE (Cont.)

8. Record the new reference voltage.

9. Repeat to obtain as many points as desired.

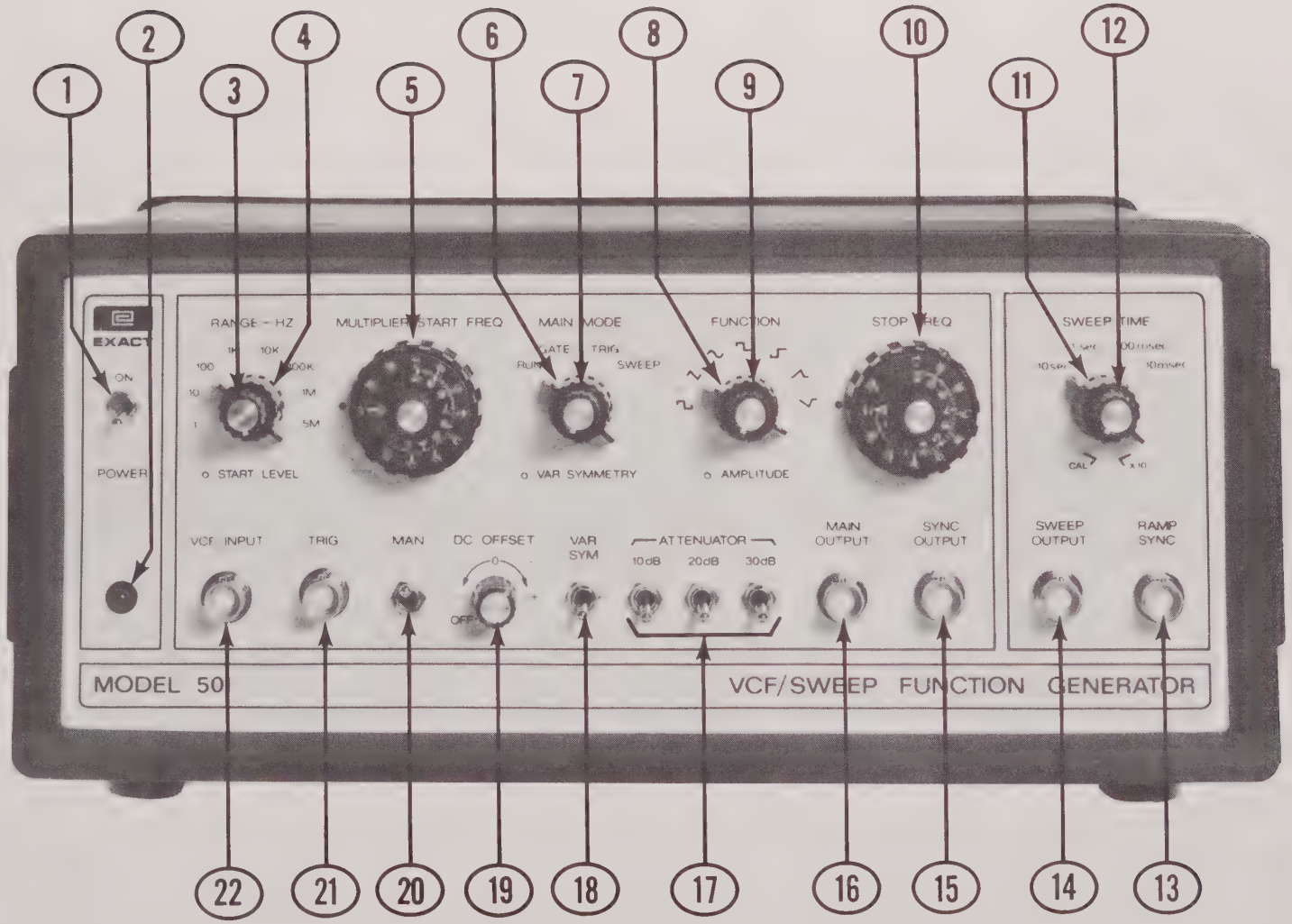
10. Calculate linearity and observe linearity is > 99%.

11. Set RANGE to 1M and repeat steps 2 through 9.

12. Calculate linearity and observe linearity is > 95%.

SECTION 2

OPERATING INSTRUCTIONS



FRONT PANEL FAMILIARITY

MODEL 501

2.1.0 FRONT PANEL FAMILIARITY

1. POWER SWITCH. Primary power switch that turns the instrument on and off.

2. POWER ON INDICATOR. Instrument pilot lamp that indicates the instrument is on when the indicator is lit.

3. START LEVEL CONTROL. Provides a variable start level or phase for the sine and triangular waveforms when the instrument is used in the GATE or TRIG mode.

4. RANGE-Hz SWITCH. Selects operating frequency range for the main output waveforms.

5. MULTIPLIER/START FREQUENCY CONTROL. Selects main output operating frequency when multiplied by RANGE-Hz setting, or the beginning frequency of a frequency sweep in the sweep mode.

6. MAIN MODE SWITCH. Selects RUN (continuous), GATE, TRIGGER or SWEEP modes for waveforms at the MAIN OUTPUT.

7. VARIABLE SYMMETRY CONTROL. Provides continuous control of the time symmetry of the main output waveforms when activated by the VAR SYM toggle.

8. FUNCTION SWITCH. Selects the waveform to be available at the MAIN OUTPUT connector.

9. AMPLITUDE CONTROL. Provides variable voltage level control of the MAIN OUTPUT waveform.

10. STOP FREQUENCY CONTROL. Selects the end frequency of a frequency sweep when multiplied by the RANGE-Hz setting.

11. RAMP TIME SWITCH. Selects the operating range for the time length of a frequency sweep.

12. VARIABLE CONTROL. Provides continuous control of the time length of a frequency sweep within the operating range as selected by the RAMP TIME switch.

13. RAMP SYNC OUTPUT. Provides an output pulse that rises and falls in voltage, coincident with the start and stop of a frequency sweep.

14. SWEEP OUTPUT. Provides a ramp waveform output from the sweep generator.

2.1.0 FRONT PANEL FAMILIARITY (Cont.)

15. SYNC OUTPUT. Provides a square waveform sync output that is coincident with the main output sine and triangle waveform peaks or the main output square waveform transitions.

16. MAIN OUTPUT. Provides the main output waveform at an internal source impedance level of 50Ω.

17. ATTENUATOR SWITCH (10dB, 20dB, 30dB). Provides step attenuation of the voltage level at the main outputs. Any combination or all of the switches may be activated providing 60dB maximum attenuation.

18. VAR SYM SWITCH. Activates the variable symmetry control. It also reduces the operating frequency of the main output waveforms by a factor of ten.

19. D.C OFFSET CONTROL. Provides a variable control for waveform D.C. level as well as a detented switch position for deactivating the control.

20. MANUAL SWITCH. Provides a manual means to gate or trigger the main output waveforms depending on which mode is selected at the MAIN MODE switch.

21. TRIG INPUT. Accepts an external voltage for gating or triggering the main output waveforms. Gate or trigger is selected by the MAIN MODE switch.

22. VCF INPUT. Accepts an external voltage for controlling the frequency of the main output waveforms.

2.2.0 OPERATION

A note about the Kelvin-Varley divider frequency multiplier vernier:

The selected vernier frequency range of the MODEL 501 covers three decades. The upper limit is selected by the RANGE-Hz selector, and the setting applies to both the MULTIPLIER/START FREQuency and STOP FREQuency dials. The "S" position on the outer dial of the START FREQuency selector switch is the "search" position, and allows the generator to be tuned over the entire three decades by the inner START FREQuency vernier. In positions other than "search", frequencies in the upper decade can be "dialed in". The STOP FREQuency dial does not have a "search" position. Frequencies in all three decades are directly "dialed in".

2.2.1 RUN MODE - FIXED FREQUENCY OPERATIONS

A. Initialize the front panel by placing the VAR SYM and ATTENUATOR toggle switches in the "OFF" or down position. Place the MAIN MODE selector at RUN.

B. Select the desired output frequency with the RANGE-Hz selector and the MULTIPLIER/START FREQuency selector. The frequency selected is available as a constant amplitude square wave at the SYNC OUT connector. This signal can be used as an external sync for oscilloscope presentations, or for frequency or period measurements on a counter-timer.

C. Select the desired output waveform with the FUNCTION selector. The waveform selected, at the frequency selected, is available at the MAIN OUT connector.

D. Adjust the output AMPLITUDE and ATTENUATOR controls as necessary. With all ATTENUATOR's off, and the AMPLITUDE control fully clockwise, the MAIN OUT connectors will provide about 15V P-P when properly terminated. The AMPLITUDE control, when used in conjunction with the ATTENUATOR switches, will provide >80dB of continuous control on output amplitude. Only the signal at the MAIN OUT connector is affected by the AMPLITUDE and ATTENUATOR controls.

E. The DC OFFSET control is available to provide ±7.5V of DC offset to the output signal when the output connector is properly terminated. Open circuit offset control is ±15V.

NOTE: DC OFFSET will be affected by the ATTENUATOR switches, but not the AMPLITUDE control.

2.2.1 RUN MODE - FIXED FREQUENCY OPERATIONS (Cont.)

F. When the RAMP mode is selected by the FUNCTION switch the RANGE-Hz switch should be set to 10KHz or less to minimize cross-talk. The ramp time is adjusted with the RAMP TIME switch and VARIABLE control.

2.2.2 SWEEP MODE - INTERNAL FREQUENCY SWEEP OPERATIONS

A. Select the desired start frequency for sweeping operations by performing the RUN MODE adjustments. The generator will produce the waveform selected, with the amplitude and DC offset selected, at the frequency of the start point of the sweep.

NOTE: The maximum frequency that can be obtained is 1.1 times the RANGE-Hz setting. The minimum is .001 times the RANGE-Hz setting.

B. Select the stop frequency, or "end-of-sweep" frequency desired, with the STOP FREQuency selector.

C. Select the RAMP TIME desired. Ramp time is continuously variable from 10msec to >100sec. The SWEEP OUTPUT connector continuously provides a ramp of zero to -2V into a 50Ω load. The period of the ramp is selected with the SWEEP TIME and CAL-X10 controls. RAMP SYNC provides a sync pulse that is positive for the duration of the sweep ramp's reset.

D. Select SWEEP on the MAIN MODE selector. The generator will produce the waveform selected, at the amplitudes and DC offsets selected, sweeping from the START FREQuency setting to the STOP FREQuency setting, at the SWEEP TIME selected.

NOTE: Any or all controls may be readjusted while sweeping. The START LEVEL control will have no effect in this mode. External connections made to GATE IN will have no effect. No connections should be made to VCF IN (see External Sweeping Operations). The SYM toggle may be activated at this time, but caution must be used (see Variable Symmetry Operations).

The generator will sweep from the START FREQuency setting to the STOP FREQuency setting regardless of which is the higher frequency. If both controls are set for the same frequency, no sweeping will occur.

2.2.3 EXTERNAL SWEEPING OPERATIONS

A. Set up the instrument in the RUN mode for the start frequency desired.

NOTE: The Kelvin-Varley Divider is, in essence, a potentiometer that will apply from zero volts to +5V to one input of a summing junction. The VCF INput connector is connected to another input of the same summing

2.2.3 EXTERNAL SWEEPING OPERATIONS (Cont.)

junction. Under no conditions should the summation of the KVD's output and VCF IN be less than zero volts or greater than +5V. The output of the KVD will be the KVD setting times +5V.

B. External signals, ramps, etc. may be applied to the VCF INput connector in any mode. The instrument will not sweep to a frequency of greater than 1.1 times the RANGE-Hz setting, nor lower than 1/1000 of the RANGE-Hz setting.

2.2.4 GATE OR BURST MODE OPERATIONS

A. Set up the function generator for the desired waveform, frequency, and amplitude as per the Run Mode operations.

B. Select GATE on the MAIN MODE selector, and adjust the START LEVEL control for the desired start phase angle of the waveform.

NOTE: The START LEVEL control adjusts the start phase of the waveform from -90° to +90°. Beyond +90°, the generator will free-run. The waveform start phase is represented by a DC level at the output. This DC level represents the instantaneous DC level of the waveform at the phase angle selected.

C. Activate MANual, and observe that the waveform selected, at the frequency selected, is present at the output for as long as MANual is activated.

D. An external signal may be applied to the GATE IN connector. The external signal must be greater than 250mV P-P. The generator will be gated "on" whenever the GATE IN signal level is greater than the trigger threshold. When the GATE IN signal passes approximately 250mV below this threshold, the generator will complete the last cycle and re-enter "lockout".

NOTE: If the GATE IN signal frequency is higher than the main generator's selected frequency, the generator may appear to free-run. The generator may also be gated on at any time by activating the MANual toggle.

2.2.5 TRIGGER OR PULSE MODE OPERATIONS

A. Trigger Mode operations are identical to Gate Mode operations except that only one cycle of the waveform will be produced at the output whenever the internal circuitry is triggered.

2.2.5 TRIGGER OR PULSE MODE OPERATIONS (Cont.)

NOTE: "One cycle" of waveform is 360° of the waveform selected. Square or Pulse waveforms will always start at the positive or the negative peak. Whenever the generator is triggered , only one peak will be displayed, as the Start Level is the same DC level as the other peak. Therefore, only a "Pulse" will be seen at the output.

CAUTION

The GATE IN signal must pass through the threshold in a positive direction to trigger the Generator. The signal must then pass below the threshold to reset the trigger circuitry. Activating the MANual toggle will produce one pulse only if the GATE IN signal is below the trigger threshold. Once MANual has been activated, no further pulses will be produced at the output until it is released.

2.2.6 VARIABLE SYMMETRY

A. Variable Symmetry is a mode of operation that can be operated during any other mode of operation. Whenever the VAR SYM toggle is activated, the MAIN OUTputs will produce a frequency that is 1/10 that of the control settings. In other words, the frequency range selected on the RANGE-Hz selector will be divided by 10.

B. The VARiable SYMMETRY control will have no effect on generator operations until the VAR SYM toggle is activated. Once activated, the VARiable SYMMETRY control will vary the duty cycle of the waveform from 5% to 95%.

2.3.0 FIRST TIME OPERATION

A. Set the front panel controls as follows:

POWER	ON
RANGE-Hz	1K
START LEVEL	MID-RANGE
MULTIPLIER/START FREQ	1.0-00
MAIN MODE	RUN
FUNCTION	TRIANGLE
AMPLITUDE	FULLY CW
STOP FREQ	.0-00
RAMP TIME	100 msec
VARIABLE	CAL
DC OFFSET	OFF
ATTENUATORS	ALL OFF
VAR SYM	OFF

B. Connect MAIN OUT to the vertical input of an oscilloscope and terminate the connection with a 50Ω feed-through terminator. Connect SYNC OUT to the EXT HORIZ IN of the oscilloscope and trigger the 'scope externally.

C. Observe a 1KHz triangle wave at approximately 15V P-P displayed. Rotate the FUNCTION selector through each of the waveforms available and observe the waveforms displayed, then select the sine wave.

D. Rotate the AMPLITUDE control to fully CCW. Note that the waveform displayed is less than 1.5V P-P. Return AMPLITUDE to fully CW.

E. Activate all ATTENUATOR toggles. Observe a 15 mV P-P signal displayed. Note that the AMPLITUDE control and ATTENUATOR toggles provide 80dB of continuous control on the output, or a range of from 15V P-P to less than 15mV P-P into a 50Ω load. Place all ATTENUATORS to OFF and AMPLITUDE to fully CW.

F. Select the SQUARE wave on the FUNCTION selector, and activate the VAR SYM toggle. Note that the output frequency is now approximately 100Hz, or 10% of the RANGE and MULTIPLIER settings. Note that the VARiable SYMMETRY control will adjust the positive portion of the wave form from 5% of the duty cycle ($\approx$ 500 μ sec) to 95% of the duty cycle ($\approx$ 9.5msec). Deactivate VAR SYM.

G. Activate the DC OFFSET control by rotating it CW. Note that the control will offset the displayed waveform by ±7.5V. Deactivate DC OFFSET by rotating the control fully CCW to the detent position.

NOTE: When MAIN OUTput is unterminated, the maximum P-P output will become 30V for waveforms, and 15V for DC OFFSET.

2.3.0 FIRST TIME OPERATION (Cont.)

H. Select SINE on the FUNCTION SELECTOR, and SWEEP on the MAIN MODE control. Move the oscilloscope's external horizontal input from SYNC OUT to SWEEP SYNC. Observe a sine wave sweeping from 1KHz to 1Hz in 100msec. Rotate the SWEEP TIME VARIABLE control to X10 and observe that the sweep time changes to more than 1 second.

I. Select GATE on the MAIN MODE control, and return the oscilloscope external sync to SYNC OUT. Observe that the oscilloscope is not triggering. Activate MANual and observe the oscilloscope triggering and a 1KHz sine wave present at the output. SYNC OUT will produce output sync pulses only when the MAIN OUTput is gated on.

Adjust the oscilloscope as necessary to produce a continuous display (i.e., auto trigger) or trigger on an external signal. Note that while MANual is deactivated a DC level is present at the output. The DC level is adjustable with the START LEVEL control. If START LEVEL is rotated fully CW, the generator will free-run. Note that the output is gated "on" for as long as MANual is held activated. Also note that the sine wave will begin, or be gated "on", at the DC level selected by the START LEVEL control, and will continue after MANual is released until the same DC level is reached.

J. Select TRIG on the MAIN MODE control. Observe that while operation is much the same as in the GATE mode, only one complete cycle of the waveform will be generated each time MANual is activated.

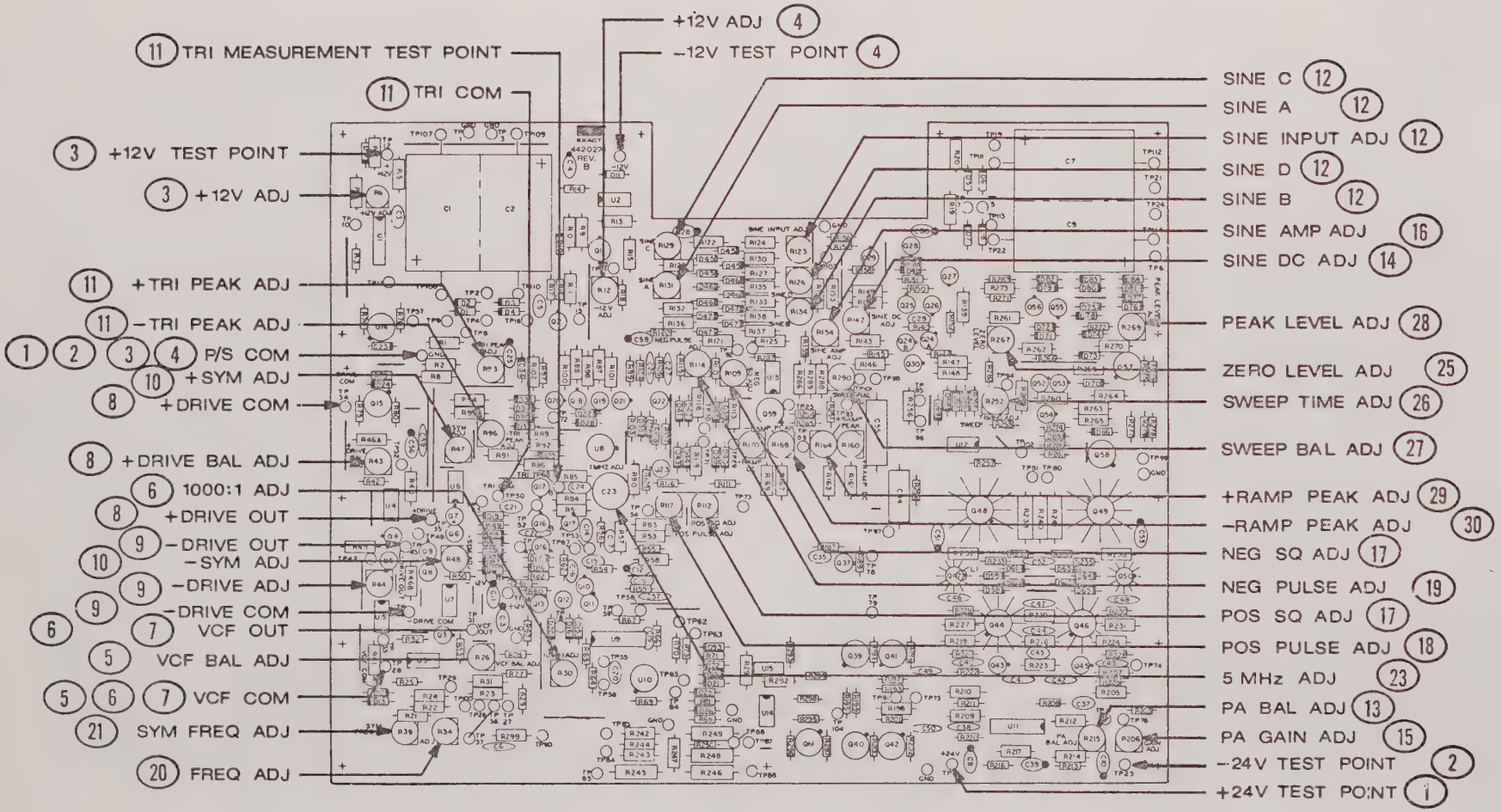
2.4.0 OPTION Y

The Y option to the MODEL 501 provides INTERNAL BURST and TRIGGER. The INTERNAL BURST mode is selected by setting MAIN MODE to GATE and STOP FREQ to the "B" position. The frequency of the signal when burst on is set by the RANGE-Hz and MULTIPLIER/START FREQ settings repetition rate by the SWEEP TIME controls, and the duty cycle of the burst by the inner dial of the STOP FREQ switch.

The INTERNAL TRIGGER mode is selected by setting MAIN MODE to TRIG and STOP FREQ to the "B" position. A single cycle waveform, whose frequency is dependent on the RANGE-Hz and MULTIPLIER/START FREQ settings and whose repetition is determined by the SWEEP TIME settings is generated. The delay of the cycle with respect to the RAMP SYNC can be varied with the inner dial of the STOP FREQ control.

SECTION 3

CALIBRATION



ADJUSTMENT LOCATION
DETAIL

3.1.0 EQUIPMENT REQUIRED FOR CALIBRATION

Oscilloscope: DC to 100MHz
5 mv/cm with differential comparator
Tektronix 7704 with 7A13 plug-in or equivalent

Counter/Timer: 5.5 MHz to 10,000 seconds
DANA 8010B or equivalent

DVM: .01% accuracy with 1,000 meg ohm floating INPUT
DANA 4300 or equivalent

Harmonic Distortion Analyzer: less than .1% residual distortion
Hewlett Packard 334 or equivalent

Spectrum Analyzer: 100KHz to 100MHz
Hewlett Packard 141T, 8552B, 8553B or equivalent

3.2.0 CALIBRATION WARM-UP

It is recommended that the instrument be operated at normal line voltage for a period of 30 minutes before calibration.

3.3.0 INITIAL CONTROL SETTINGS FOR CALIBRATION

Refer to Section 2 Front Panel Familiarity

POWER SWITCH	ON
START LEVEL	MID RANGE
RANGE-Hz	100K
MULTIPLIER/START FREQ	1.0
MAIN MODE	RUN
VAR SYMMETRY	MID RANGE
FUNCTION	TRIANGLE
AMPLITUDE	MAX CLOCKWISE
STOP FREQ	1.0
RAMP TIME	100mSEC
RAMP TIME VARIABLE	CAL
ATTENUATOR	DEACTIVATED
VAR SYM	DEACTIVATED
DC OFFSET	OFF

3.4.0 CALIBRATION

1. Use the 100 volt DC range on the digital voltmeter, and connect the test leads between power supply common and the +24V test point. Check for 24 ± 1V.

2. Connect the digital voltmeter between power supply common and the -24V test point. Check for -24 ± 1V.

3. Use the 10.00 volt DC range on the digital voltmeter, and connect the test leads between power supply common and the +12V test point. Adjust the +12V ADJ for a reading of +12.00 ± 0.010 volts.

4. Connect the digital voltmeter between power supply common and the -12V test point. Adjust the -12V ADJ for a reading of -12.00 volts ± 0.010 volts.

5. Use the 100.0 millivolt DC range on the digital voltmeter, and connect the test leads between VCF common and the VCF INput BNC connector. Adjust the VCF BAL ADJ for a reading of 0.00 volts ± 0.5 millivolt.

6. Change the MULTIPLIER/START FREQ control to read S-O. Both inner and outer dial should be maximum counter clockwise. Use the 100.0 millivolt DC range on the digital voltmeter, and connect the test leads between VCF common and the VCF out test point. Adjust the 1000:1 ADJ for a reading -.0045 volts ± 0.5 millivolt.

7. Change the MULTIPLIER/START FREQ control to read 0.1. Use the 1.00 volt DC range, and connect the test leads between VCF common and the VCF out test point. Record the reading obtained for future reference. The reading obtained would normally be between -0.400 volts and -0.500 volts.

8. Use the 1.000 volt DC range on the digital voltmeter, and connect the test leads between + DRIVE COM and the + DRIVE OUT test point. Adjust the + drive BAL ADJ for a voltage reading equal to the voltage reading obtained in Step 7, ±0.001 volts. Example: If the reading in Step 7 was -473.0 millivolts, the adjustment of the + DRIVE BAL ADJ would be for 473.0 millivolts ± 0.001 volts.

9. Use the 1.000 volt DC range on the digital voltmeter, and connect the test leads between - DRIVE COM and the - DRIVE OUT test point. Adjust the - DRIVE BAL ADJ for a positive voltage reading equal to the absolute value of the negative voltage reading obtained and recorded in Step 7. Example: If the reading in Step 7 was a -473.0 millivolts, the adjustment of the - driver BAL ADJ would be for +473.0 millivolts ± 0.001 volts.

3.4.0 CALIBRATION (Cont.)

10. Change the MULTIPLIER/START FREQ dial to read S-O (Both dials fully counter clockwise). Using the oscilloscope set for 2 volts per division vertical and 1 millisecond per division horizontal, connect the 50Ω main output to the oscilloscope vertical input with a 50Ω coaxial cable and a 50Ω terminator. Connect the sync output to the oscilloscope External trigger input. Preadjust the +SYM ADJ and the -SYM ADJ so that one complete cycle of the triangle waveform is viewed on the oscilloscope. Notice as these adjustments are made that each adjustment will affect only one slope of the waveform. Adjust the +SYM ADJ for the corresponding slope to be 6 divisions (6 ms) on the oscilloscope ± 0.2 divisions. Change the oscilloscope trigger polarity as necessary to view each slope. Adjust the -SYM ADJ so that the other slope is 6 divisions (6 ms) ± 0.2 divisions.

11. Reset MULTIPLIER/START FREQ dial to 1.0 and the RANGE-Hz switch to 1K. Connect the oscilloscope to the triangle measurement test point using a X10 low capacity probe. Set the oscilloscope vertical controls using the comparison voltage differentially so that the triangle peak voltage can be measured within 5 millivolts. Adjust the +TRI PEAK ADJ for a positive peak voltage of 1.250 volts ±5 millivolts. Readjust the oscilloscope control to measure the negative peak and adjust the -TRI PEAK ADJ for -1.250 volts ± 5 millivolts.

12. Set the FUNCTION selector to sine waveform and connect the harmonic distortion analyzer to the main output 50Ω terminated with a 50Ω load. Set the analyzer to read sine distortion. Adjust the SINE INPUT ADJ, Sine A, Sine B, Sine C, and Sine D adjustments for minimum sine distortion. It may be necessary to readjust these adjustments as there is interaction between them.

13. Reset the FUNCTION selector to triangle output. Rotate the AMPLITUDE control to fully counter clockwise. Adjust the P.A. BAL ADJ so that the positive and negative peaks are of equal amplitude ± 10 millivolts.

14. Rotate the FUNCTION selector to sine waveform and adjust the SINE D.C. ADJ so that the sine waveform has equal positive and negative peaks within 10 millivolts.

15. Reset the FUNCTION selector to Triangle output. Select 1K on the RANGE-Hz selector. Rotate the AMPLITUDE control fully clockwise for maximum output level. Adjust the oscilloscope as necessary to view each peak at 0.5V per centimeter vertical deflection. Adjust the P.A. GAIN ADJ so that the peak voltages at +7.5 to +7.8 volts, and -7.5 to -7.8 volts.

16. Select Sine on the FUNCTION selector, and adjust the SINE AMP ADJ so that the peak voltages are +7.5 to +7.8 volts, and -7.5 to -7.8 volts.

3.4.0 CALIBRATION (Cont.)

17. Select Square on the FUNCTION selector and adjust the POS SQ adj and NEG SQ ADJ so that the peak voltages are +7.5 to +7.8 and -7.5 to -7.8.

18. Select Positive Pulse on the FUNCTION selector and adjust the POS PULSE ADJ for +7.5 to +7.8.

19. Select Negative Pulse on the FUNCTION selector and adjust the NEG PULSE ADJ for -7.5 to -7.8.

20. Select Square on the FUNCTION selector and connect the 50Ω MAIN OUT to a frequency counter, terminated in 50Ω. Select 10K on the RANGE-Hz selector. Adjust FREQ ADJ for 10K ± 200Hz.

21. Activate SYM. Adjust the SYM FREQ ADJ for 1K ± 20Hz.

22. Deactivate SYM. Select 5M on the RANGE-Hz selector, and 0.1 on the MULTIPLIER/START FREQ selector. Adjust the .5MHz ADJ (mounted on the RANGE-Hz switch) for 500K ± 10KHz.

23. Select 1.0 on the MULTIPLIER/START FREQ selector. Adjust the 5MHz ADJ for 5M ± 100KHz. Repeat Steps 22 and 23.

24. Select 1M on the RANGE-Hz selector. Adjust the 1MHz ADJ (mounted on the RANGE-Hz switch) for 1MHz ± 200Hz.

25. Connect oscilloscope vertical to SWEEP OUT terminated in 50Ω. Trigger the oscilloscope on SWEEP SYNC OUT. Set the vertical display for 1V per centimeter, and the horizontal display for 20msec per centimeter. Observe two complete ramp waveforms per sweep of the oscilloscope. Adjust ZERO LEVEL for a ramp starting voltage of 0.0 ± .01 volts.

26. Change the oscilloscope horizontal sweep rate to 10msec per division. Adjust the SWEEP TIMING ADJ for a ramp period of 100 ± 1msec.

27. Connect the oscilloscope vertical to MAIN OUT 50Ω. Trigger the oscilloscope on SYNC OUT. Set the horizontal display for 0.1msec per division. Select 10K on the RANGE-Hz selector. Select 1.0 on the MULTIPLIER/START FREQ selector. Select SWEEP (on) on the MAIN MODE selector. Adjust the SWEEP BAL ADJ until no jitter is present in the waveform displayed.

28. Set RANGE-Hz to 1MHz. Set STOP FREQ to 0.0. Set oscilloscope horizontal to 2μ sec/div. Set the PEAK LEVEL ADJUST so the portion of the oscilloscope trace where the main generator stops running equals one minor division (.4μ sec).

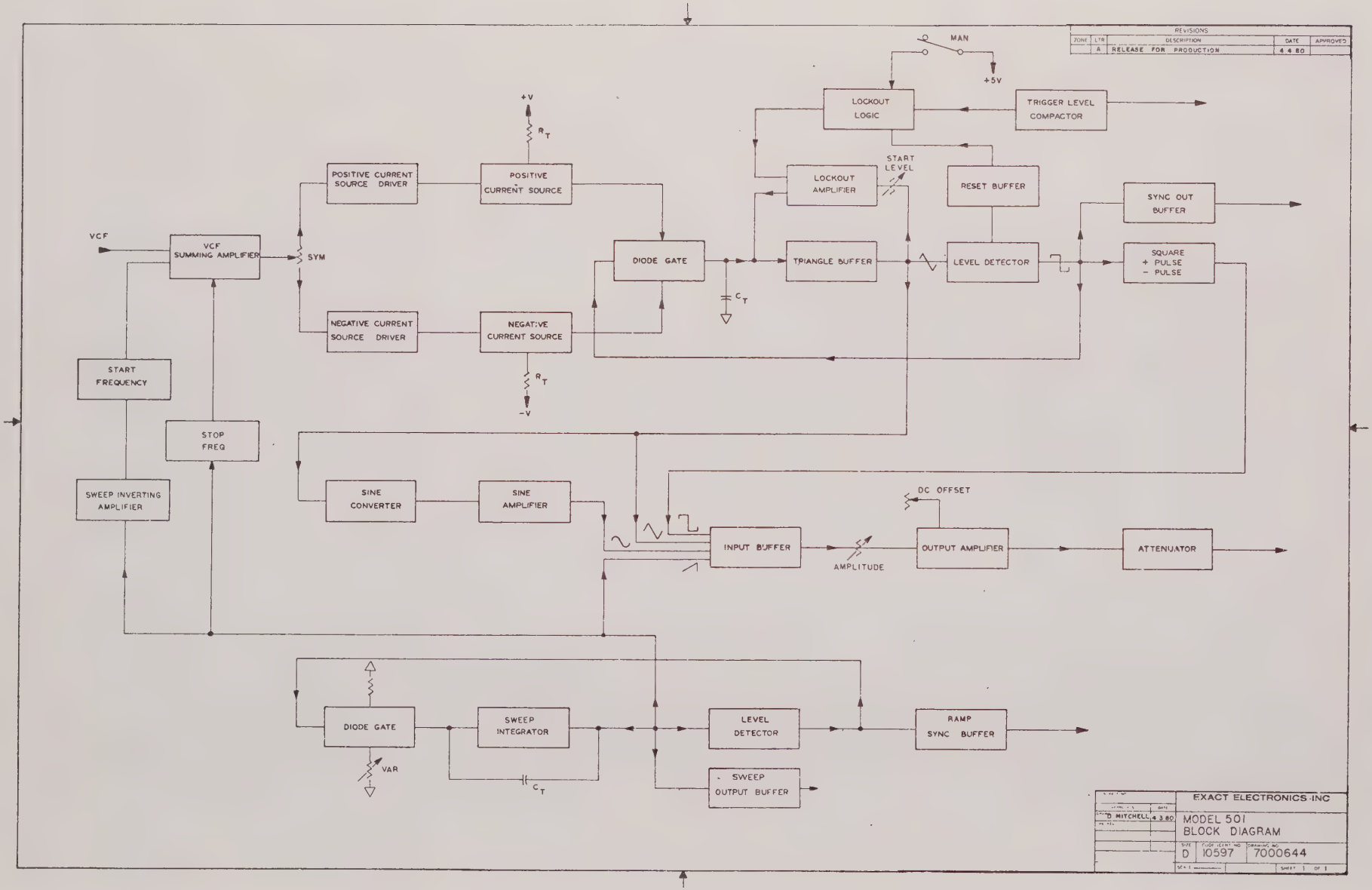
3.4.0 CALIBRATION (Cont.)

29. Select Positive Ramp on the FUNCTION selector and adjust +RAMP PEAK for a positive peak voltage of +7.5 to +7.8 volts.

30. Select Negative Ramp on the FUNCTION selector and adjust -RAMP PEAK for a negative peak voltage of -8.5 to -7.8 volts.

SECTION 4

CIRCUIT DESCRIPTION


REVISIONS
ZONE | LTR | DESCRIPTION | DATE | APPROVED
A | RELEASE FOR PRODUCTION | 4.4.80
MAN
+5V
LOCKOUT LOGIC
TRIGGER LEVEL COMPACTOR
+V
R_T
POSITIVE CURRENT SOURCE DRIVER
POSITIVE CURRENT SOURCE
START LEVEL
LOCKOUT AMPLIFIER
RESET BUFFER
SYNC OUT BUFFER
VCF
VCF SUMMING AMPLIFIER
SYM
DIODE GATE
C_T
TRIANGLE BUFFER
LEVEL DETECTOR
SQUARE
+ PULSE
- PULSE
NEGATIVE CURRENT SOURCE DRIVER
NEGATIVE CURRENT SOURCE
R_T
-V
START FREQUENCY
STOP FREQ
SWEEP INVERTING AMPLIFIER
SINE CONVERTER
SINE AMPLIFIER
DC OFFSET
INPUT BUFFER
AMPLITUDE
OUTPUT AMPLIFIER
ATTENUATOR
DIODE GATE
VAR
SWEEP INTEGRATOR
C_T
LEVEL DETECTOR
SWEEP OUTPUT BUFFER
RAMP SYNC BUFFER
EXACT ELECTRONICS INC
D MITCHELL 4.3.80
MODEL 501
BLOCK DIAGRAM
SIZE D
FSCM IDENT NO 10597
DRAWING NO 7000644
SHEET 1 OF 1

4.1.0 THEORY OF OPERATION

The theory of operation of the Model 501 Function Generator is given in two parts. The first section covers the block diagram Figure 4.1 of the main generator and the ramp sweep generator. The second part is a detailed description of the generator circuitry with component designations given for direct reference to the schematic diagrams (Section 6).

4.2.0 BLOCK DIAGRAM

The basic generator loop utilized in this waveform generator consists of a pair of current sources alternately charging and discharging a timing capacitor. The triangular waveform generated in this timing capacitor is applied to a high input impedance triangle buffer amplifier which then applies the triangular signal to the bistable level detector. The output of this level detector is then fed back to alternately switch the current sources, thus the loop is closed forming a free running generator. The level detector is used to switch the current sources at a predetermined point on the triangle, thereby generating a constant amplitude triangle regardless of frequency of operation. Having generated a triangle of constant amplitude, the frequency then is proportional to the timing capacitance and the current supplied to the capacitor from the constant current sources. Decade values of frequency are selected by decade selection of the timing capacitors and/or decade selection of the constant current sources. For alternately charging and discharging the range capacitors, one constant current source is a positive source and the other is a negative. In order that these can be externally controlled with a single DC voltage, a pair of level shifting amplifiers is supplied that converts a single input voltage to the voltages necessary to drive the positive and negative current sources. The positive and negative level shifting amplifiers are driven by the single VCF amplifier that can accept a signal either from the generator multiplier dial or from an external DC voltage. The multiplier dial receives its signal from a constant voltage amplifier called the sweep inverting amplifier.

This basic generator loop by nature provides a triangular waveform and a square waveform that can be processed and used as output signals to provide two waveforms. The triangular waveform can be processed through the sine converter to provide a sinusoidal waveform. The triangular waveform available at the output of the triangle buffer can be applied directly to a buffer amplifier through the function switching network. This then provides the triangular output waveform. The square waveform from the level detection network is applied through a diode switching network to the function switch. For sinusoidal operation, the triangular waveform from the triangle buffer is supplied through the function switching network to the sine converter. The output of the sine converter is then fed to a sine amplifier which boosts the operating voltage level of the waveform. This waveform is then applied back through the function switching network to the buffer amplifier. The buffer amplifier utilized in this generator is used to boost the operating signal amplitudes generated by the basic generator loop to a level

4.2.0 BLOCK DIAGRAM (Cont.)

suitable for processing in the power amplifier. The output of this buffer amplifier is applied directly to the amplitude potentiometer which selects the amplitude applied to the power amplifier. The power amplifier can accept not only this amplitude signal but offset signals from the variable offset control. The output of the power amplifier is directly applied to the step attenuator which can attenuate the signal in fixed dB steps. Output of the attenuator is the main output connector for the generator.

There are six regulated power supplies in this generator, two of them being derived from unregulated raw voltages available directly at the filter capacitors. One of these raw voltages is a nominal ±36 volts which is stepped down through regulators for a plus 24 volt supply and a minus 24 volt supply. The plus and minus 24 volt supplies are used to provide voltage for the power amplifier. The other unregulated supply is a nominal ±30 volts which is stepped down through plus and minus 12 volt regulators to provide operating potentials necessary for operation of most of the other circuitry. The final supply provides a regulated +5 volts for the logic circuitry.

In order to lockout the main generator loop when operating in the gate or trigger mode, a lockout amplifier is used. This amplifier provides a sink for the current - from the positive and negative current sources - which is normally supplied to charge and discharge the timing capacitor. The lockout amplifier is enabled by a signal from the main generator lockout logic circuitry. The lockout level may be varied between the positive and negative peaks of the output waveform amplitude with a front panel START LEVEL control which establishes the reference bias for the lockout amplifier.

The ramp sweep generator produces the required ramp waveform for internally sweeping the main generator. The ramp waveform is generated by using an operational amplifier as an integrator to convert a constant input current to a linear ramp. A diode gate alternately connects the positive and negative timing resistors to produce the ramp waveform. Switching of the diode gate is accomplished with a signal produced by the level detector. A sweep sync output buffer is used to prevent loading of the level detector by the sweep sync output.

A stop frequency control varies the ramp amplitude supplied to a VCF input of the main generator. In the sweep mode it is necessary to control the ramp amplitude in order to vary the sweep width. A buffer amplifier provides the necessary power and isolation for driving the sweep output.

4.3.0 CIRCUIT DESCRIPTION

SUMMING AMPLIFIER

U3 is an operational amplifier connected for a voltage gain of -1. The start frequency multiplier dial (S3) forms a voltage divider providing approximately 0 to +5V to the summing amplifier input (TP27). By varying the applied input voltage, the signal to the constant current source drivers can be varied, thus providing a method for changing the timing current and thus the frequency. The summing amplifier inverts the applied input voltage. When S3 (Mult) is in the search mode, the vernier (R14) is connected between TP27 and ground to supply a 1000:1 voltage ratio, thus a 1000:1 frequency deviation. The main timing adjust potentiometers (R34-38) establish the gain of the summing amplifier to obtain the correct timing during calibration. D12 and D13 provide input protection for the μA741 operational amplifier.

The VCF input is connected to the summing amplifier at TP26, providing an external source of frequency control. By applying voltage at the VCF input, the frequency may be varied as with the multiplier dial. The applied input voltage will add to or subtract from that established by the multiplier dial setting. If the multiplier dial is set at position 1.0, approximately +5V is applied to the input of the summing amplifier. If a positive voltage is now applied to the VDF input jack, the summing amplifier will saturate. If -5V is applied at the VCF input jack, this will add to the +5V applied by the multiplier dial and the resultant input voltage will approach 0V, driving the summing amplifier output to approximately 1/1000 of the frequency of the range switch and multiplier settings. If the multiplier dial were in the search mode of operation and set at approximately 0V input at TP27 by the search vernier (R14), the frequency would be approximately 1/1000 of the range setting. By applying +5V at the VCF input jack, the two voltages will sum, establishing approximately +5V at the summing amplifier input. This will cause the frequency to increase to approximately the frequency of the range setting.

TP100 is the internal sweep input, which is connected to the ramp generator when in the sweep mode of operation. The frequency may be swept to the frequency indicated by the range switch and stop frequency control from any other frequency determined by the start frequency control within a three decade range (1000:1). The ramp waveform amplitude is controlled by the start and stop frequency controls to provide the desired amount of sweep. The VCF Balance (R26) compensates for the offset in the summing amplifier, establishing a 0V reference at the summing amplifier input. The output of the summing amplifier is approximately 0V to -5V and drives the positive and negative current source drivers.

POSITIVE AND NEGATIVE CONSTANT CURRENT SOURCE DRIVERS

The output of the summing amplifier (OV to -RV) is connected to U4, the positive current source driver, through R40. U4 and Q4 provide a constant current source in the feedback loop of the positive current source driver. U4 will turn on Q4 until a feedback current equal to the input current through R40 is equalized. This current causes a voltage drop across R46A which equals the voltage drop across R40.

U5 in conjunction with Q5 make up the negative current source driver. The output signal from U3 summing amplifier is connected to U5 operational amplifier at the non-inverting input. U5 is connected as a voltage follower. Q5 establishes a constant current equal to the input voltage - R41. This constant current causes a voltage drop equal to the output voltage of the summing amplifier, across R46B, exactly equal to and of opposite polarity of that across R46A.

VARIABLE SYMMETRY

Variable Symmetry switch S1008 is a 3PDT toggle switch. S1008 is connected across the symmetry control potentiometer and across R39. In the off position, the switch sections short the potentiometers, disabling the variable symmetry control. This allows the main generator to output symmetrical sine, square or triangle waveforms, or positive pulse, negative pulse, positive ramp, or negative ramp waveforms with 50% duty cycles. All waveforms are at the frequency indicated by the range switch and multiplier control.

When the variable symmetry switch is turned on, a 20K ohm variable resistor is connected between the output of the summing amplifier U3 and the positive and negative current source drivers, U4 and U5. This causes the indicated frequency to be divided by a factor of 10. The sine, square, and triangle waveform can be made non-symmetrical to the point where one portion of the waveform has a time duration 19 times greater than the other. The positive pulse, negative pulse, positive ramp, and negative ramp waveforms can be varied from a 5% to 95% duty cycle. R39, SYM FREQ ADJ, adjusts the gain of U3 to provide a frequency division of 10 during variable symmetry operations.

POSITIVE AND NEGATIVE CONSTANT CURRENT SOURCE

U6, U7, Q6, Q7, Q8, and Q9 are the positive and negative constant current sources that supply the constant timing current to charge and discharge the timing capacitor. U6 operational amplifier and Q6 and Q7 FET's are connected to form a constant current source. The signal across R46A is connected to U6 operational amplifier at the non-inverting input. This causes a constant current E(R2A) - R(R2A) to charge the timing capacitor when the diode gate is turned on, connecting the positive current source. The FET's (Q6 and Q7)

POSITIVE AND NEGATIVE CONSTANT CURRENT SOURCE (Cont.)

prevent loading of the current sources at very low timing currents (1000:1). The positive symmetry adjustment R47 compensates for offset current in the operational amplifier U6.

U7 operational amplifier and Q8 and Q9 FET's provide the negative current needed to charge the timing capacitor in exactly the same way. The negative symmetry adjustment R48 compensates for offset current in the operational amplifier U7.

The diode gate is made up of D89, D90, D91, and D92. The timing capacitors are connected at TP47 through the range switch, which also switches the timing resistors. The gate switching signal is connected at the junction of D89 and D91. When the gate signal is positive, D91 is forward biased and sinks the timing current from the negative current source, thus disconnecting the negative current source. D92 is now reversed biased, allowing timing current to charge the timing capacitor through D90 from the positive current source. When the gate signal switches negative, D89 is forward biased, thus sinking the positive timing current through D89. D91 is now reverse biased, allowing timing current to charge the timing capacitor from the negative current source through D92. D14 is connected to the lockout amplifier and sinks the timing current during the lockout modes.

TRIANGLE BUFFER

Q16A and B and Q17A and B serve as a unity gain, high input impedance buffer for the triangle generated at TP47. Q17A FET prevents loading of the current sources by its very high input impedance. Q16A is a source follower driving Q17A, an emitter follower. Q17B provides offset and temperature compensation for Q17A, while Q16B provides offset and temperature compensation for Q16A.

Transistor array U8A, B, and C is a differential amplifier used as a level detector. U8C is a constant current source for differential amplifier U8A and U8B. The reference level at the base of U8B is determined by one of the current sources connected by the diode gate, D30-33. D27 and D28 limit the collector swing of the differential amplifier to improve high frequency response. The level detector collectors drive a non-saturating current mode switch. This is a bistable switch having both a differential input and differential output. One output, Q20, drives the level detector reference gate, the reset buffer, the sync output buffer and the current source gate. R93 and R96 adjust the positive and negative trip points of the level detector, establishing the positive and negative peaks of the triangle. The other output, Q21, provides the square wave signal for the output amplifier. D34 is a Zener diode which decreases the collector supplies from -12V to approximately -7V for Q20, Q21, and Q23 to limit power dissipation.

SQUARE BUFFER

The square buffer, Q22 and Q23, is used to prevent loading of the bistable switch and to drive the diode gate, D27, D28, D39, and D40. The diode gate provides fast rise and fall time of the square waveform which will be fed to the output amplifier section. Resistors R109 and R112 allow adjustment of the positive and negative peaks of the square wave. Two additional diode gates are driven by the square buffer output. Diodes D41 and D42 form a positive level gate which will feed a positive pulse referenced to ground when the mode switch selects positive pulse. D43 and D44 form a negative level gate which will feed a negative pulse referenced to ground when the mode switch selects negative pulse. R114 and R117 are used to adjust the positive and negative peak levels respectively.

SYNC OUTPUT BUFFER

The square signal from the bistable switch is fed to the input of the sync output buffer Q14 and Q15. These complimentary transistors privide > 4V peak to peak open circuit output from a 50 ohm source impedance. The output will be 2V peak to peak or greater when driving any resistive load down to 50 ohms.

LOCKOUT AMPLIFIER

The lockout amplifier is a differential amplifier which compares the triangle waveform to a fixed reference established by the START LEVEL adjustment. Q10 and Q11 form the input stage which drives Q12 and Q13, the output stage. D16 is a zener diode used as a collector clamp for Q10 to keep it out of saturation. Q13 collector is connected to D14, the lockout diode connected to the current source gate at TP42 (the input of the triangle buffer).

D20 enables and disables the output stage. During run, D20 is forward biased, keeping Q13 turned off. With Q13 off, D14, the lockout diode, is reverse biased and the generator free runs. During lockout, D20 is reverse biased, enabling the lockout amplifier. As the triangle charges toward its negative peak, the base of Q10 goes negative until Q10 turns off sufficiently to cause Q13 to turn on. When Q13 turns on sufficiently, it will forward bias D14, sinking the timing current from the negative current source. The level at the point of lockout is determined by the input divider to the lockout amplifier, R51, R52, and R53. D17 to D19 provide collector clamping for Q13 to prevent saturation.

MAIN GENERATOR LOCKOUT LOGIC GATE

U9 is a quadruple 2 input positive nor gate, which provides the necessary logic function to operate the lockout amplifier. In the run mode of operation, the trigger level comparator (U10) supplies a logical "1" at one input

MAIN GENERATOR LOCKOUT LOGIC GATE (Cont.)

of U9A (pin 2). As long as this logical "1" is present, the output of U9A (pin 1) will remain a "0". A "0" at pin 1 will forward bias D20, disabling the lockout amplifier, causing Q13 to remain "off", or in a run condition, as previously explained. In the gate mode of operation, the trigger level comparator supplies a "0" to the logic input (U9A, pin 2). The output will remain a "0", keeping D20 forward biased until a "1" is applied at the other input (pin 6).

The pulse to U9B (pin 6) is coincident with the square wave from the level detector. When the square is in the proper phase relationship, a positive pulse or "1", is connected to the logic input (pin 6), which will cause the output of U9A, pin 1 to go to a logical "1", thus reverse biasing lockout diode D20. D20 will remain reverse biased in a lockout condition until U9A (pin 2) goes to a logical "1" level or positive.

TRIG LEVEL COMPARATOR

U10 is a high speed differential comparator providing DC coupled triggering and gating modes for the main generator logic gate.

Run Mode:

In the run mode, -12V is applied to the inverting input of U10 through S4. This assures that the non-inverting input always remains more positive than the inverting input. This causes U10 output to remain positive or in the run mode of operation. The non-inverting input of the comparator is protected by clipping diodes D21 and D22.

Gate Mode:

In the gate mode, the -12V from S4 is disconnected, causing U10 inverting input (pin 3) to go to a more positive state than the non-inverting input. This switches the output of the comparator to its negative or "0" state. The "0" from the comparator places the logic gate in a lockout condition. The generator will remain in a lockout condition until signal is received at the comparator input (pin 2).

In the gate mode, the trigger comparator input is connected through S4 to the gate input connector. Any signal equal to or greater than 2V will cause the trigger level comparator to turn on, placing the logic gate in a "run" condition. When the input signal is removed or falls below 2V, the comparator will allow the logic gate to return to its lockout condition.

Trigger Mode:

The only difference between the gate and trigger modes of operation is that the output of the comparator is AC coupled to the logic gate instead of DC

TRIG LEVEL COMPARATOR (Cont.)

coupled. When the trigger signal causes the comparator to turn on, the positive output of the comparator AC couples a differentiated positive pulse into the logic gate, placing it in a run condition. The duration of this pulse is very short, allowing the logic gate input to return to a "0" or a lockout condition even though the comparator may still be "on" in its positive state. C19 will couple a "1" into the logic gate upon completion of the first cycle and cause the generator to lock out. The external trigger signal must be removed, allowing the comparator to reset before another pulse can be coupled into the logic gate. One complete cycle will be generated each time a signal equal to or greater than 2V is applied at the gate input.

Sweep Mode:

In the sweep mode, the generator is placed in a run condition by the -12V at S4. All trigger signal paths are disconnected. The sweep generator is connected to the sweep inverting amp and the STOP FREQ control through S4. This allows the main generator to be swept in frequency. Stop frequency and sweep time control settings determine the upper frequency and rate parameters to which the main generator frequency will be swept.

MANUAL GATE/TRIGGER SWITCH

The manual toggle switch (S9) is connected to the gate/trigger switch debounce network U9C and D. These are two input nor gates making up the second half of the quadruple 2 input nor gate referred to under MAIN GENERATOR LOCKOUT LOGIC GATE. S9 keeps one input of the nor gate, U9 pin 12 at "0" and pin 9 at +5V or "1" With pin 9 at "1", the output (pin 10) will remain at "0". This output is connected through D25 to the trigger input TP63 of the trigger level comparator via the main mode switch. When the manual toggle (S9) is actuated, pin 12 of U9 is set to "1" causing its output pin 13 and the input pin 8 to go to "0". R66 sets pin 9 to "0". The two "zeros" present at the inputs of U9 cause the output (pin 10) to go to a "1" or positive state. This "1" is coupled through D25 to the trigger level comparator input and will remain until S9 is released.

SINE CONVERTER

The sine converter network receives its signal from the function selector only when a sine waveform is selected. The triangle is connected at TP92. R122 through R124 form a voltage divider to correctly match the triangle amplitude to the converter network. The triangular input voltage is applied to all three of the diode switching bridges simultaneously, and the output of these bridges is summed together in a single resistor R125. Resistors R130, R135, and R138 are used to provide voltage breaking points that allow the currents

SINE CONVERTER, Cont.

to be changed in successive addition as the input voltage to the sine converting network goes from zero volts to a positive or negative voltage. The sine waveform then appearing at the output summing resistor R125 is applied to the input of the sine amplifier at Q24A.

SINE AMPLIFIER

This sine wave is amplified by differential amplifier Q24A and B. Q30 is a constant current source for the input differential stage. Sine DC adjustment (R142) compensates for offset in the input pair, establishing a 0V reference at the sine output. A second differential stage is driven by Q24A and B. The output across R152 is connected to the output buffer (Q28 and Q29) through an emitter follower (Q27). The output (TP81) is connected through feedback resistors R153 and sine amplifier adjustment R154 to the inverting input. The buffered sine wave output is connected to S5, the function switch.

BUFFER AMPLIFIER

The preconditioned sine, square, triangle, positive pulse, negative pulse, positive ramp and negative ramp waveforms are all connected to the indicated positions of S5. The selected waveform from S5 is applied directly to the buffer amplifier which consists of complementary transistors Q41 and Q42, and drivers Q39 and Q40.

The signals available from the output of the buffer amplifier are processed through de-coupling resistor R198 to the amplitude front panel control resistor. This potentiometer and its bottoming resistor R203 provide a vernier control of the output amplitude of the generator. These signals are applied directly through gain controlling potentiometer R206 and amplitude setting resistor R205 to the input of the closed loop output amplifier. The variable DC offset can also be applied through its switch S13 to a gain setting resistor R2-7 and to the input of the amplifier. The value of the amplitude control resistors and DC offset control resistors are chosen such that the output amplitude will be limited to a maximum of 20V peak to peak open circuit and the DC offset limited to a maximum of ±5V peak open circuit.

OUTPUT AMPLIFIER

The output amplifier has two signal paths for processing the input signals, one for low frequency signals from DC to approximately 100KHz and the other for frequencies of approximately 100KHz and above. The higher frequency signal path flows from the input connection through capacitors C41 and C42 to the bases of the two cascode amplifiers. One amplifier is transistors Q43 and Q44 and the other is transistors Q45 and Q46. The signals are simultaneously applied

OUTPUT AMPLIFIER, (Cont.)

to the output emitter followers. Diodes D58 through D65 are bias diodes for generating a quiescent current for the input emitter follower stages Q47 through Q50. Biad diodes D61 and D63 provide a quiescent bias for the output transistors Q48 and Q49. Degeneration resistors R237 and R238 apply the signal directly to the gain setting feedback resistor R218 and the output impedance resistors R239 through 241. The cascode amplifier referenced to the positive supply Q43 and Q44 is operated at a slightly higher current than the cascode amplifier referenced to the negative supply. This higher current allows a small bias current to be drawn through R220 by the differential amplifier U11C U11D. This connection allows injection of the DC and low frequency signals to be processed through the amplifier. The low frequency input signals are coupled from the input connection through resistor R208 to the base of the differential amplifier U11A. The differential output from this amplifier is applied directly to the differential amplifier U11C and U11D. The single ended output from U11D is applied directly to the cascode through R220. Resistor R215 allows compensation for the voltage offset in the differential amplifier U11.

The attenuator is a series of T pad attenuators that can be either switched in or out by the toggles in the front panel of the instrument. These T pad attenuators are arranged such that the 50 ohm and 600 ohm transmission line impedance is maintained regardless of which or how many of the attenuators is activated. The 600 ohms is obtained by adding 550 ohms in series with the 50 ohm output.

RAMP SWEEP GENERATOR

The sweep generator uses a ramp integrator to generate a linear ramp over a range of 10 milliseconds to 100 seconds. The sweep time switch selects one of two integrating capacitors and the variable 10:1 control establishes a bias level for a resistive negative current source.

The integrator is made up of operational amplifier U12 and C54, 55, or 60. The output of the integrator is connected to the front panel main mode switch at TP102.

The level detector consists of transistors Q52 through Q56. Q54 is a constant current source providing operating currents for differential pair Q52 and Q53. The differential pair is used to compare the ramp voltage at the emitter of Q51 to a reference voltage established at R268. When the ramp reaches a certain level, the differential pair changes state. Q55 and Q56 which are connected differentially to the collectors of Q52 and Q53 also change state. The collector of Q56 goes positive, switching the diode gate D66 through D69 quickly discharging the selected capacitor through resistor R255. The reference level at R268 was also switched negative by Q55. The ramp voltage

RAMP SWEEP GENERATOR (Cont.)

must therefore reach a level that will cause the base of Q52 to be more negative than the reference before the bistable switch will again change back to the original state. Zero level adjustment R267 is used to set the ground or zero reference of the sweep output voltage. Peak level adjustment R269 sets the peak voltage of the sweep output. Q57 and Q58 are complementary transistors used for the sweep sync output. This output is at approximately -2V when the sweep voltage is increasing. At the peak of the sweep, a positive pulse is produced having an amplitude of 2 volts open circuit from a 50 ohm source. The pulse width is equal to the fall time of the sweep voltage.

The output of U12 is fed through the main mode switch in the sweep position, and through resistors R290 and R288 to the inverting input of U13. U13 is an operational amplifier and is used with buffer Q59 to invert the sweep voltage. When the main mode switch is in the sweep position, the collector of Q59 is connected through a resistor network to the VCF input of the main generator. U12 output is also connected to the inverting input of U14 through R291. U14 and Q61 make up the sweep output buffer amplifier. This amplifier has a gain of -1 and will output a ramp waveform of -4 volts peak open circuit or -2 volts peak into a 50 ohm load. The output impedance is 50 ohms. The stop frequency is a ten position switch with vernier. The dial reading is multiplied by the range switch setting to determine the stop frequency of a sweep. When the main frequency multiplier and the stop frequency multiplier are set to the same value the sweep width will be zero. The sweep balance adjustment R290 is used to set the balance of the two waveforms fed to the VCF amplifier.

POWER SUPPLY

The primary power for this instrument is supplied through the line cord to fuse F1, and then qpplied through the main power switch S1 to the transformer primary. Transformer T1 steps down the operating potentials of the input primary power so that the proper voltage is developed through the usage of diode bridged D1 through 4, and D5 through 8 and their associated filter capacitors. The full wave center tapped bridge rectifier D1 through 4, and filter capacitors C1, C2 provide both positive and negative operating potentials of sufficient magnitude to be regulated through the use of the plus and minus 12 volt regulators. The instrument power indicator D1 is operated from the unregulated +20V supply. Integrated circuit U1 is a self-contained voltage reference and error amplifier. The output of this error amplifier is fed to series pass transistor Q1 which enhances the current carrying capability of U1. Resistor R4 is a current sensing resistor that allows U1 to reduce the output voltage of the supply in the event the current reaches a predetermined value. The voltage feedback, necessary for the error amplifier, is derived through the use of the voltage divider R5 through R7.

POWER SUPPLY (Cont.)

The potentiometer R6 provides for a vernier adjustment in the power supply voltage. Diode D9 is used to prevent accidental application of negative voltage to the positive regulator. Application of negative voltage would damage the integrated circuit. Capacitor C4 prevents the build up of transient voltage at the output of the supply under varying load conditions. Integrated circuit U2 and transistors Q1 and Q2 provide a regulation of the negative raw voltage such that a minus 12 volts is produced. This regulator utilizes the positive 12 volt supply as a reference. Resistor R11 and R12 form a voltage divider between the positive 12 volts and the inverting input of U2. The adjustable potentiometer R12 provides a calibration adjustment for the -12V supply. The output of U2 is offset by Zener diode D10 to keep the operational amplifier output level within safe limits. Q2 is an emitter follower which drives the series pass transistor Q2. Feedback resistor R13 establishes the proper amount of negative feedback. Q1 senses the output current through R15 providing short circuit limiting at about 500ma. Capacitor C121 prevents a voltage buildup due to transient loading on the output of the power supply. Diode D11 prevents accidental damage in the event of application of a reverse bias voltage to this supply.

Full wave center tapped bridge rectifier D5 through D8, and filter capacitors C7, C9 provide both positive and negative operating potentials of sufficient magnitude to be regulated through the use of the plus and minus 24 volt regulators. The ±24 volt regulators are 3-pin integrated circuits, U1 and U2.

The +5 volt supply is a 3-pin integrated circuit, U15, connected to the +12 volt supply as its source.

SECTION 5

PARTS LIST

CODE LIST OF MANUFACTURERS

Code No.	Manufacturer	Address
[illegible]	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00334	Humidell Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Prod. Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00915	Northern Eng. Labs, Inc.	Burlington, Wis.
00853	Sangamo Electric Co. Orchil Div. (Capa)	Marion, Illinois
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01295	TRW Semiconductors Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Prod. Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Inc.
01599	Pacific Relays, Inc.	Van Nuys, Calif.
01609	Amorack Corp.	Rockford, Illinois
01681	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp/Amar.	Saugerties, N.Y.
02285	Cole Mfg. Co.	Palo Alto, Calif.
02400	Amphenol-Borg El. Corp.	Chicago, Illinois
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vaculine Company of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine and Tool Co.	Dayton, Ohio
03777	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03878	Pyrofilm Resistor Co.	Morrison, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04013	Taune Corp.	Lambertville, N.J.
04062	Elmenco Products Co.	New York, N.Y.
04222	MI-Q, Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co. Electronics Div.	Burbank, Calif.
04354	Precision Paper Tube Co.	Chicago, Illinois
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04451	Sylvania Electric Prod., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola/Semicon. Prod.	Phoenix, Arizona
04732	Filmon Co/Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Illinois
04777	Automatic Elect. Sales Corp.	Northlake, Illinois
04796	Sequoia Wire/Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P.M. Motor Co.	Chicago, Illinois
05006	20th Century Plastics	Los Angeles, Calif.
05277	Westinghouse/Semicon. Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Marcos, Calif.
05393	Illuminonic Eng. Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Illinois
05728	Tiffen Optical Co.	Roslyn Heights, L.I., N.Y.
05729	Metropolitan Telecomm. Corp Metro Cap Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical	Rochester, N.Y.
06402	E.T.A. Products/Amer.	Chicago, Illinois
06473	Western Devices, Inc.	Inglewood, Calif.
06540	Amatom Elect. Hardware Co.	New Rochelle, N.Y.
06555	Beede Electrical Inst. Co.	Penacook, N.H.
06751	U.S. Semicon Div. of Nuclear Corp/Amer.	Phoenix, Ariz.
06812	Torrington Mfg Co., West Div.	Van Nuys, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07115	Corning Glass Works Electronics Comp. Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07127	Transistor Electronics Corp.	Minneapolis, Minn.
07128	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Bircher Corp.	Los Angeles, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Siliconix Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Labs	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert, Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario
08717	Sloan Company	Burbank, Calif.
08718	Cannon Elect Co., Phoenix Div.	Phoenix, Ariz.
08792	CBS Elect. Semiconductor Oper., Div. C.B.S., Inc.	Lowell, Mass.
09084	Mal-Fab	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Arahm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Illinois
09569	Mallory Battery Co/Canada Ltd.	Toronto, Ontario, Canada
09664	The Bristol Company	Waterbury, Conn.
10214	Gen. Trans. Western Corp.	Los Angeles, Calif.
10411	Ti-Tel, Inc.	Berkeley, Calif.
10597	Enact Electronics, Inc.	Hillsboro, Oreg.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Tel. of Calif., Inc.	S. Pasadena, Calif.
11302	Microwave Elect. Corp.	Palo Alto, Calif.
11536	Duncan Electronic, Inc.	Santa Ana, Calif.
11711	Gen'l Inst/Semiconductor Div	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.

Code No.	Manufacturer	Address
	Metoks, Inc.	Palo Alto, Calif.
	Philadelphia Handle Co.	Camden, N.J.
	Clarostat Mfg. Co.	Dover, N.H.
	Nippon Elect. Co., Ltd.	Tokyo, Japan
	Delta Semiconductor Inc.	Newport Beach, Calif.
	Thermalloy	Dallas, Texas
12136	Telefunken (G.M.B.H.)	Hannover, Germany
12196	Midland Mfg. Co.	Kansas City, Kansas
12294	Sam-Tech	Newbury Park, Calif.
12481	Calif. Resistor Corp.	Santa Monica, Calif.
12490	American Components Inc.	Conshohocken, Pa.
12615	Cornell Dubilier El. Corp.	So. Plainfield, N.J.
12760	Williams Mfg. Co.	San Jose, Calif.
12803	Webster Elect., Co., Inc.	Racine, Wis.
12894	Adjustable Bushing Co.	N. Hollywood, Calif.
12954	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
13606	The Dovan Co.	Livingston, N.J.
13637	Spruce Pine Mica Co.	Spruce Pine, N.C.
13655	Computer Diode Corp.	Lodi, N.J.
13693	De Jur-Amsco Corp.	Long Island City, N.Y.
13699	Delco Radio, Division of G.M. Corp.	Kokomo, Ind.
13706	Thermometrics, Inc.	Canoga Park, Calif.
13724	Tronex Company	Mountain View, Calif.
13744	Radio Industries	Des Plaines, Illinois
13815	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
13839	E.I. Dupont and Co., Inc.	Wilmington, Del.
13873	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
13909	Thomas A. Edison Industries Div. McGraw-Edison Co.	West Orange, N.J.
13917	Electra Manufacturing Co.	Kansas City, Mo.
13919	Electronic Tube Corp.	Philadelphia, Pa.
13921	Executive, Inc.	New York, N.Y.
13927	Fansteel Metallurgical Corp.	No. Chicago, Illinois
13928	The Fafnir Bearing Co.	New Britain, Conn.
13934	Fed. Telephone and Radio Corp.	Clifton, N.J.
13936	General Electric Co.	Schenectady, N.Y.
13937	G.T. Lamp Div.	Nela Park, Cleveland, Ohio
13950	General Radio Co.	W. Concord, Mass.
13954	Gries Reproducer Corp.	New Rochelle, N.Y.
13957	Groset Fila Co/America, Inc.	Carlstadt, N.J.
13959	Hamilton Watch Co.	Lancaster, Pa.
13960	Hewlett-Packard Co.	Palo Alto, Calif.
13965	GE Receiving Tube Dept.	Owensboro, Ky.
13970	Lectrohm, Inc.	Chicago, Ill.
13994	Stamyck Corp.	Hawkesburn, Ontario, Cd.
13997	P.R. Mallory and Co., Inc.	Indianapolis, Ind.
14006	Machlett Laboratories Prod.	Springdale, Conn.
14009	Miniature Precision Bearings	Keene, N.H.
14030	Motor Co.	Chicago, Illinois
14033	C.A. Norgren Co.	Englewood, Colo.
14035	Ohmite Mfg. Co.	Skokie, Illinois
14042	Palomar Corp.	Cambridge, Mass.
14050	Precision Thermometer/Inst.	Philadelphia, Pa.
14071	Raytheon Company	Lexington, Mass.
14078	Rowan Controller Co.	Baltimore, Md.
14080	Ward Leonard Electric	Mt. Vernon, N.Y.
14085	Shallcross Mfg. Co.	Selma, N.C.
14088	Simpson Electric Co.	Chicago, Illinois
14093	Sonotone Corp.	Elmsford, N.Y.
14099	Sorenson and Co., Inc.	S. Norwalk, Conn.
14102	Speer Carbon Co., Inc.	Fonrowanda, N.Y.
14115	Sprague Electric Co.	N. Adams, Mass.
14119	Teles, Inc.	St. Paul, Minn.
14120	Thomas and Betts Co.	Elizabeth, N.J.
14127	Triplett Electrical Inc.	Bluffton, Ohio
14129	Union Switch and Signal, Div. Westinghouse Air Brake Co.	Swissvale, Pa.
14132	Universal Electric Co.	Owosso, Mich.
14137	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
14138	Western Electric Co., Inc.	New York, N.Y.
14140	West Inst./Div. Daystrom	Newark, N.J.
14145	Wiltek Manufacturing Co.	Chicago, Illinois
14150	Wollensak Optical Co.	Rochester, N.Y.
14154	Allen Manufacturing Co.	Hartford, Conn.
14157	Allied Control Co., Inc.	New York, N.Y.
14159	Almetal Screw Prod. Co, Inc.	Garden City, N.Y.
14161	Atlantic India Rubber Works	Chicago, Illinois
14162	Amperite Co., Inc.	New York, N.Y.
14179	Belden Manufacturing Co.	Chicago, Illinois
14183	Bird Electronic Corp.	Cleveland, Ohio
14186	Bimbach Radio Co.	New York, N.Y.
14191	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
14193	Bud Radio Inc.	Cleveland, Ohio
14194	Camloc Fastener Corp.	Paramus, N.J.
14195	Allen D. Cardwell Elect. Prod. Corp.	Plainville, Conn.
14196	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
14197	Chicago Condenser Corp.	Chicago, Illinois
14199	CTS Corp.	Elkhart, Ind.
14200	Cannon Electric Co.	Los Angeles, Calif.
14201	Cornmar Engineering Co.	Burbank, Calif.
14202	C.P. Clare and Co.	Chicago, Illinois
14204	Centralab, Div. Globe Union, Inc.	Milwaukee, Wis.
14205	Commercial Plastics Co.	Chicago, Illinois
14210	The Conrtuh Wire Co.	New York, N.Y.
14211	Chicago Miniature Lamp Wks	Chicago, Illinois
14220	A. O. Smith Corp. Crowley Div.	West Orange, N.J.
14225	Cinch Mfg. Corp.	Chicago, Illinois
14232	Dow Corning Corp.	Midland, Mich.
14233	Eitel-McCullough, Inc.	San Bruno, Calif.
14238	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
14239	Cinch Graphik Co., Inc.	Providence, R.I.
14240	John E Fast and Company	Chicago, Illinois
14241	Dialight Corp.	Brooklyn, N.Y.
14242	General Ceramics Corp.	Keasby, N.J.
14243	General Instrument Corp. Semiconductor Div.	Newark, N.J.
14245	Girard-Hopkins	Oakland, Calif.
14246	Drake Mfg. Co.	Chicago, Illinois
14247	Hugh H. Eby, Inc.	Philadelphia, Pa.
14248	Gudeman Co.	Chicago, Illinois
14249	Robert M. Hadley Co.	Los Angeles, Calif.
14252	Erie Resistor Corp.	Erie, Pa.
14253	Hansen Mfg. Co., Inc.	Princeton, Ind.
14254	H. M. Harper Co.	Chicago, Illinois
14255	Hellpot, Div. Beckman Instruments, Inc.	Fullerton, Calif.

Code No.	Manufacturer	Address
73293	Hughes Products Div. of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Philips Co., Inc.	Hicksville, N.Y.
73490	Beckman Helipot Corp.	S. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73637	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Illinois
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73845	Goshen Stamping and Tool	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite, Inc.	Neptune, N.J.
74455	J. H. Winne and Sons	Winchester, Mass.
74515	Industrial Condenser Corp.	Chicago, Illinois
74538	R.F. Prod. Div. of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75473	Jones, Howard B., Div. of Cinch Mfg. Corp.	Chicago, Illinois
75579	James Knights Co.	Sandwich, Illinois
75332	Kulka Electric Corp.	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Illinois
75915	Littlefuse, Inc.	Des Plaines, Illinois
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marsdel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Crystal Lake, Illinois
77068	Bandis Pacific Div. of Bendix Corp.	N. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostron Instrument and Electronic Co.	S. Pasadena, Calif.
77250	Photti Manufacturing Co.	Chicago, Illinois
77252	Philadelphia Steel and Wire Corporation	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine/Foundry	Princeton, Ind.
77620	Radio Condenser Co.	Camden, N.J.
77638	Rosie Reception Co., Inc.	Brooklyn, N.Y.
77664	Resistance Products Co.	Harrisburg, Pa.
77769	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof, Div. of Illinois Tool Works	Elgin, Illinois
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn, Inc.	Pitman, N.J.
78452	Thompson-Bremer and Co.	Chicago, Illinois
78471	Tilley Manufacturing Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Illinois
79727	Continental-Wirt Elect. Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco, Div. of Sessions Clock Company	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Assoc. And brand tube meeting EIA standards.	Washington D.C.
80207	Unimax Switch, Div. of W L Maxson Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Illinois
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro, Div. Robertshaw Fulton Controls Co.	Columbus, Ohio
80486	All Star Products, Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammond Mfg. Co., Inc.	New York, N.Y.
80640	Stevens, Arnold Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Graybill Co.	LaGrange, Illinois
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co.	Norwalk, Conn.
81349	Military Specifications	[illegible]
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div. Industrial Tube Oper.	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Illinois
82142	Jaffery Electronics, Div. of Speer Carbon Co.	DuBois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod., Electronic Tube Div.	Emporium, Pa.
82376	Astron Company	E. Newark, N.J.
82389	Switchcraft, Inc.	Orange, Illinois
82647	Metals and Controls, Inc., Div. Texas Instruments, Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wisc.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83003	Western Washer Mfr. Co.	Los Angeles, California
83058	Carr Fastener Co.	Cambridge, Mass.
83066	New Hampshire Ball Bearing	Peterborough, N.H.
83125	Pyranid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp/Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Illinois
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Illinois
83501	Gavitt Wire and Cable Co., Div. Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.

Code No.	Manufacturer	Address
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Lloyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Nebr.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Co.	Boonton, N.J.
85474	B.M. Broadcasting and Co.	San Francisco, Calif.
85660	Knited Knods, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Illinois
85197	Clifton Precision Products	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	harrison, N.J.
87216	Philco Corp. (Lansing Div.)	Lansing, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco
87664	Van Waters and Rogers, Inc.	Seattle, Wash.
87930	Tcmer Mfg. Co.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Illinois
88270	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89462	Weldes Kohinoar, Inc.	Cambridge, Mass.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89836	Carrer Parts Div. of Economy Baker Co.	Chicago, Illinois
89865	United Transformer Co.	Chicago, Illinois
90699	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Illinois
91506	Augat Brothers', Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia
91737	Gremar Mfg Co., Inc.	Wakefield, Mass.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Illinois
91965	Nohm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92196	Universal Metal Prod., Inc.	Basset Puente, Calif.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.
93332	Sylvania Electric Prod, Inc. Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93788	Howard J. Smith, Inc.	Port Monmouth, N.J.
93929	G.V. Controls	Livingston, N.J.
93983	Ineuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Mfg. Co., Industrial Comp. Div. Rec. Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div. Calif. St. Plt	Newton, Mass.
94148	Scientific Radio Products	Loveland, Colo.
94154	Turg-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp. Electronics Div.	E. Paterson, N.J.
94222	Southco, Div. S. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod., Div. Model Engineering and Mfg. Co.	Chicago, Illinois
94330	Wire Cloth Products, Inc.	Chicago, Illinois
94682	Worcester Pressed Alum. Corp.	Worcester, Mass.
95023	Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Blomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Illinois
95712	Dage Electric Co., Inc.	Franklin, Ind.
95987	Wechesser Co.	Chicago, Illinois
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Div. of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner, Div. Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Curtiss Screw Co.	Chicago, Illinois
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg.	Yonkers, N.Y.
97966	CBS Electronics Div. C.B.S., Inc.	Danvers, Mass.
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers, Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	S. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Coast Corp.	Redwood City, Calif.
98721	General Mills	Minneapolis, Minn.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Div. Controls Co. of America	El Segundo, Calif
99800	Delevan Electronics Corp.	E. Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Illinois
99957	Technology Instrument Corp. of California	Newbury Park, Calif.

PART	DESCRIPTION	EXACT NO	MFR
A0 CHASSIS ASSY			
A0C1001	CAPACITOR, MAIN TIMING SET	2950004	
A0C1002	CAPACITOR, 8-50 PF, VAR	2810022	72982
A0C1003	CAPACITOR, 120 PF 500V	2810534	53021
A0C1004	CAPACITOR, 8-50 PF, VAR	2810022	72982
A0D1001	LED	1520002	
A0J1001	CONNECTOR, BNC	1310047	02660
A0J1002	CONNECTOR, BNC	1310047	02660
A0J1003	CONNECTOR, BNC	1310047	02660
A0J1004	CONNECTOR, BNC	1310047	02660
A0J1005	CONNECTOR, BNC	1310047	02660
A0J1006	CONNECTOR, BNC	1310047	02660
A0P1001	CORD, POWER 3 COND	1750203	10597
A0Q1001	TRANSISTOR, 2N4921	1564921	01295
A0Q1002	TRANSISTOR, 2N4918	1564918	01295
A0R1001	RESISTOR, 8.06K MATCHED PAIR	3128061	24546
A0R1002	RESISTOR, 806Ω MATCHED PAIR	3128060	24546
A0R1003	RESISTOR, 80.6K MATCHED PAIR	3128062	24546
A0R1004	RESISTOR, 1.5M 1/4W 5%	3070155	01121
A0R1005	RESISTOR, 15M 1/4W 5%	3070156	01121
A0R1006	TO		
A0R1028	RESISTOR, 100Ω 1/8W	3181000	
A0R1029	RESISTOR, SELECT		
A0R1030	RESISTOR, SELECT		
A0S1001	SWITCH, TOGGLE SPDT	2600103	
A0S1002	SWITCH, RANGE-HZ	2600501	10597
A0S1003	SWITCH, START FREQ MULT	2600313	10597
A0S1004	SWITCH, MAIN MODE	2600703	10597
A0S1005	SWITCH, FUNCTION	2610503	10597
A0S1006	SWITCH, STOP FREQ	2600313	10597
A0S1007	SWITCH, RAMP TIME	2600404	
A0S1008	SWITCH, TOGGLE 3PDT	2600417	09353
A0S1009	SWITCH, TOGGLE SPDT MOM	2600412	09353
A0S1010	SWITCH, DPDT	2600413	09353
A0S1011	SWITCH, DPDT	2600413	09353
A0S1012	SWITCH, DPDT	2600413	09353
A0S1013	SWITCH, DC OFFSET	2600411	
A0T1001	TRANSFORMER, POWER	1200057	
A0U1001	REGULATOR, +24V MC7824P	1587824	04713
A0U1002	REGULATOR, -24V MC7924P	1587924	04713
A0	FUSEHOLDER	1360103	75915
A0	PANEL, FRONT	3890427	10597
A0	PANEL, REAR	3890428	10597
A0	CASE ASSY		
A0	CASE ASSY W/HANDLE	4380501	
A0	MANUAL, INSTRUCTION	0100591	10597
A1 MAIN PCB ASSY			
A1C0001	CAPACITOR, 950 µF 50V	2900066	90201
A1C0002	CAPACITOR, 950 µF 50V	2900066	90201
A1C0003	CAPACITOR, 470 PF 500V	2810539	53021
A1C0004	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0005	CAPACITOR, 100 PF 500V	2810537	53021
A1C0006	NOT ASSIGNED		
A1C0007	CAPACITOR, 950 µF 50V	2900066	90201
A1C0008	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0009	CAPACITOR, 950 µF 50V	2900066	90201
A1C0010	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0011	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0012	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0013	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0014	CAPACITOR, 56 PF 500V	2810561	53021
A1C0015	CAPACITOR, 47 PF 500V	2810532	53021
A1C0016	CAPACITOR, 68 PF 500V	2810523	53021
A1C0017	CAPACITOR, 10 PF 500V	2810529	53021
A1C0018	CAPACITOR, 47 PF 500V	2810532	53021
A1C0019	CAPACITOR, 220 PF 500V	2810555	53021
A1C0020	CAPACITOR, 220 PF 500V	2810555	53021
A1C0021	CAPACITOR, 22 PF 500V	2810530	53021
A1C0022	CAPACITOR, .001 µF 100V	2830000	90201
A1C0023	CAPACITOR, 8-50 PF VAR	2810022	53021
A1C0024	CAPACITOR, SELECT		
A1C0025	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0026	CAPACITOR, .05 µF 100V	2830010	90201
A1C0027	CAPACITOR, .05 µF 100V	2830010	90201
A1C0028	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0029	CAPACITOR, 100 PF 500V	2810537	53021
A1C0030	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0031	CAPACITOR, 5 PF	2810501	53021
A1C0032	NOT ASSIGNED		
A1C0033	NOT ASSIGNED		
A1C0034	NOT ASSIGNED		
A1C0035	NOT ASSIGNED		
A1C0036	NOT ASSIGNED		
A1C0037	CAPACITOR, SELECT		
A1C0038	CAPACITOR, .05 µF 100V	2830010	90201
A1C0039	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0040	CAPACITOR, .05 µF 100V	2830010	90201
A1C0041	CAPACITOR, .05 µF 100V	2830010	90201
A1C0042	CAPACITOR, .05 µF 100V	2830010	90201
A1C0043	CAPACITOR, SELECT		
A1C0044	CAPACITOR, .05 µF 100V	2830010	90201
A1C0045	CAPACITOR, .05 µF 100V	2830010	90201
A1C0046	CAPACITOR, .001 µF 100V	2830000	90210
A1C0047	CAPACITOR, .05 µF 100V	2830010	90210
A1C0048	CAPACITOR, .001 µF 100V	2830000	90210
A1C0049	CAPACITOR, .001 µF 100V	2830000	90210
A1C0050	CAPACITOR, .001 µF 100V	2830000	90210
A1C0051	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0052	CAPACITOR, .05 µF 100V	2830010	90201
A1C0053	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0054	CAPACITOR, 1.0 µF	2900022	84411
A1C0055	CAPACITOR, .1 µF	2900021	14655
A1C0056	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0057	CAPACITOR, .05 µF 100V	2830010	90201
A1C0058	CAPACITOR, 6.8 µF 35V	2900043	99515
A1C0059	CAPACITOR, .05 µF 100V	2830010	90201
A1C0060	CAPACITOR, .01 µF	2900019	
A1C0061	CAPACITOR, 220 PF	2810555	53021
A1D0001	TO		
A1D0009	DIODE, 1N4001	1524001	31718
A1D0010	DIODE, ZENER 1N756A	1520756	31718
A1D0011	DIODE, 1N4001	1524001	31718
A1D0012	TO		
A1D0015	DIODE, 1N914	1520914	31718
A1D0016	DIODE, ZENER 1N748	1520748	31718
A1D0017	TO		
A1D0033	DIODE, 1N914	1520914	31718
A1D0034	DIODE, ZENER 1N753	1520753	31718
A1D0035	TO		
A1D0044	DIODE, 1N914	1520914	31718
A1D0045	DIODE, MATCHED SET	1530777	31718
A1D0046	DIODE, MATCHED SET	1530777	31718
A1D0047	DIODE, MATCHED SET	1530777	31718
A1D0048	DIODE, 1N914	1520914	31718
A1D0049	DIODE, 1N914	1520914	31718
A1D0050	TO		
A1D0057	NOT ASSIGNED		
A1D0058	TO		
A1D0065	DIODE, 1N914	1520914	31718
A1D0066	TO		
A1D0069	DIODE, 1N484A	1521541	01295
A1D0070	TO		
A1D0087	DIODE, 1N914	1520914	31718
A1D0088	NOT ASSIGNED		
A1D0089	TO		
A1D0092	DIODE, FD777	1520777	31718
A1D0093	DIODE, 1N753A	1520753	31718
A1Q0001	TRANSISTOR, 2N3643	1563643	07263
A1Q0002	TRANSISTOR, 2N4121	1564121	07263
A1Q0003	TRANSISTOR, 2N4250	1564250	07263
A1Q0004	TRANSISTOR, 2N2484	1562484	07263
A1Q0005	TRANSISTOR, 2N4250	1564250	07263
A1Q0006	TRANSISTOR, 2N5462	1564250	07263
A1Q0007	TRANSISTOR, 2N5462	1565462	07263
A1Q0008	TRANSISTOR, 2N5485	1565485	07263
A1Q0009	TRANSISTOR, 2N5485	1565485	07263
A1Q0010	TRANSISTOR, MPS6543	1566543	07263
A1Q0011	TRANSISTOR, MPS6543	1566543	07263
A1Q0012	TRANSISTOR, 2N4258	1564258	07263
A1Q0013	TRANSISTOR, 2N4258	1564258	07263
A1Q0014	TRANSISTOR, 2N2219	1562219	07263
A1Q0015	TRANSISTOR, 2N2905	1562905	07263
A1Q0016	TRANSISTOR, MATCHED PAIR	1575485	07263
A1Q0017	TRANSISTOR, MATCHED PAIR	1573646	07263
A1Q0018	TRANSISTOR, 2N3640	1563640	07263
A1Q0019	TRANSISTOR, 2N3640	1563640	07263
A1Q0020	TRANSISTOR, 2N4121	1564121	07263
A1Q0021	TRANSISTOR, 2N4121	1564121	07263
A1Q0022	TRANSISTOR, 2N3646	1563646	07263
A1Q0023	TRANSISTOR, 2N3640	1563640	07263
A1Q0024	TRANSISTOR, MATCHED PAIR	1573646	07263
A1Q0025	TRANSISTOR, 2N4121	1564121	07263
A1Q0026	TRANSISTOR, 2N4121	1564121	07263
A1Q0027	TRANSISTOR, 2N3646	1563646	07263
A1Q0028	TRANSISTOR, 2N3646	1563646	07263
A1Q0029	TRANSISTOR, 2N4121	1564121	07263
A1Q0030	TRANSISTOR, 2N3646	1563646	07263
A1Q0031	TRANSISTOR, 2N4121	1564121	07263
A1Q0032	TO		
A1Q0038	NOT ASSIGNED		
A1Q0039	TRANSISTOR, 2N2905	1562905	07263
A1Q0040	TRANSISTOR, 2N2219	1562219	07263
A1Q0041	TRANSISTOR, 2N2219	1562219	07263
A1Q0042	TRANSISTOR, 2N2905	1562905	07263
A1Q0043	TRANSISTOR, 2N4258	1564258	07263
A1Q0044	TRANSISTOR, 2N2905	1562905	07263
A1Q0045	TRANSISTOR, 2N3646	1563646	07263
A1Q0046	TRANSISTOR, 2N2219	1562219	07263
A1Q0047	TRANSISTOR, 11587	1560087	02195
A1Q0048	TRANSISTOR, 2N2219	1562219	07263
A1Q0049	TRANSISTOR, 2N2905	1562905	07263
A1Q0050	TRANSISTOR, 2N4121	1564121	07263
A1Q0051	NOT ASSIGNED		
A1Q0052	TRANSISTOR, 2N3646	1563646	07263
A1Q0053	TRANSISTOR, 2N3646	1563646	07263
A1Q0054	TRANSISTOR, 2N3646	1563646	07263
A1Q0055	TRANSISTOR, 2N4121	1564121	07263
A1Q0056	TRANSISTOR, 2N4121	1564121	07263
A1Q0057	TRANSISTOR, 2N2219	1562219	07263
A1Q0058	TRANSISTOR, 2N2905	1562905	07263
A1Q0059	TRANSISTOR, 2N2219	1562219	07263
A1Q0060	NOT ASSIGNED		
A1Q0061	TRANSISTOR, 2N2905	1562905	07263
A1R0001	RESISTOR, 2.2K 1/4W ±5%	3070222	01121
A1R0002	RESISTOR, 3K 1/2W ±5%	3010302	01121
A1R0003	RESISTOR, 1.2K 1/4W ±5%	3070122	01121

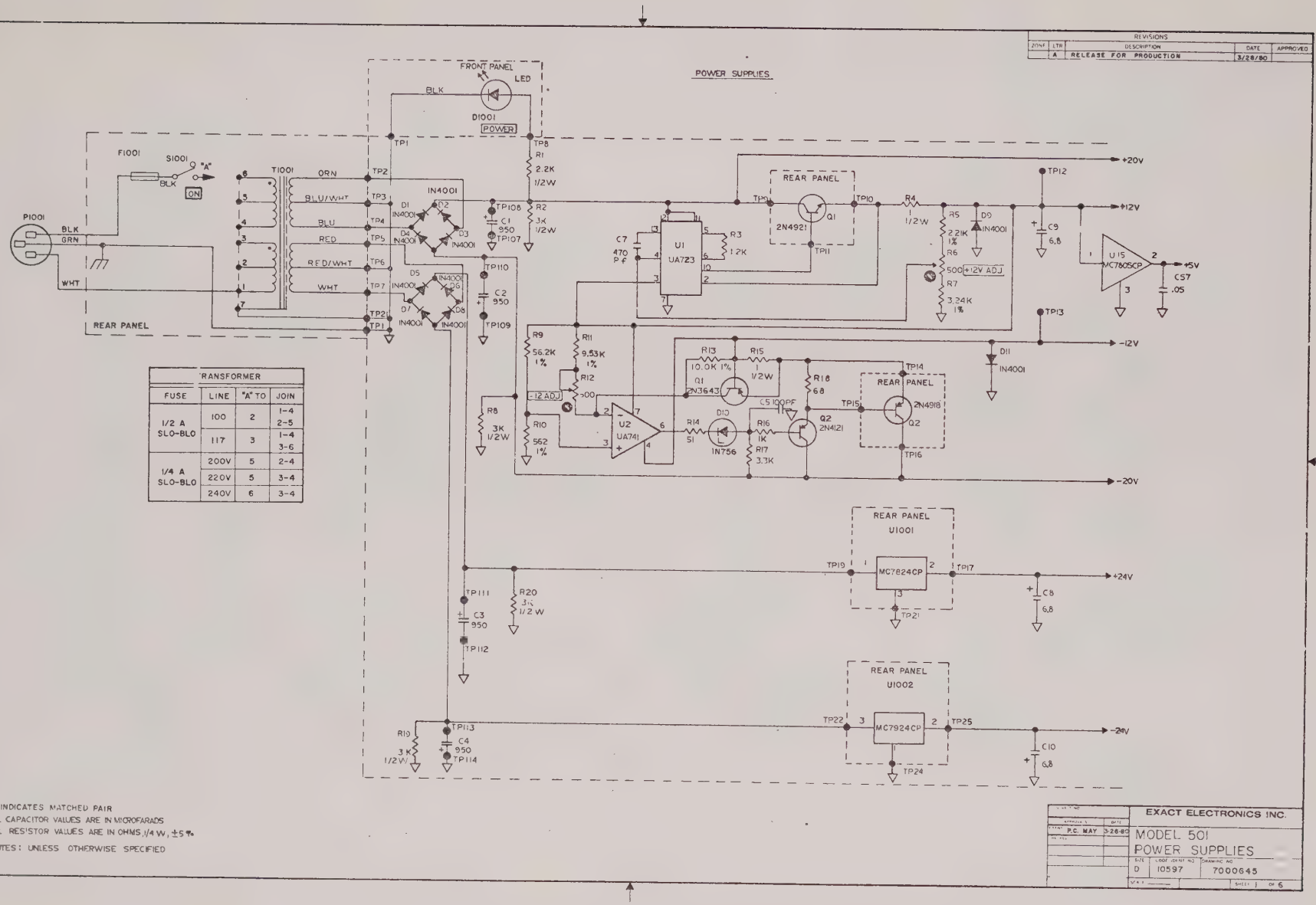
PART	DESCRIPTION	EXACT NO	MFR
A1R0004	RESISTOR, 1Ω 1/2W ±5%	3010010	01121
A1R0005	RESISTOR, 2.21K 1/4W ±1%	3132211	24546
A1R0006	POTENTIOMETER, 500Ω	3110346	11237
A1R0007	RESISTOR, 3.24K 1/4W ±1%	3133241	24546
A1R0008	RESISTOR, 3K 1/2W ±5%	3010302	01121
A1R0009	RESISTOR, 56.2 1/4W ±1%	3135622	24546
A1R0010	RESISTOR, 562 1/4W ±1%	3135620	24546
A1R0011	RESISTOR, 9.53K 1/4W ±1%	3139531	24546
A1R0012	POTENTIOMETER, 500Ω	3110346	11237
A1R0013	RESISTOR, 10K 1/4W ±1%	3131002	24546
A1R0014	RESISTOR, 51 1/4W ±5%	3070510	01121
A1R0015	RESISTOR, 1Ω 1/2W ±5%	3010010	01121
A1R0016	RESISTOR, 1K 1/4W ±5%	3070102	01121
A1R0017	RESISTOR, 3.3K 1/4W ±5%	3070332	01121
A1R0018	RESISTOR, 68Ω 1/4W ±5%	3070680	01121
A1R0019	RESISTOR, 3K 1/2W ±5%	3010302	01121
A1R0020	RESISTOR, 3K 1/2W ±5%	3100302	24546
A1R0021	RESISTOR, 28.0K 1/4W ±1%	3132802	24546
A1R0022	RESISTOR, 24.9K 1/4W ±1%	3132492	24546
A1R0023	RESISTOR, 24.9K 1/4W ±1%	3132492	24546
A1R0024	RESISTOR, 24.9K 1/4W ±1%	3132492	24546
A1R0025	RESISTOR, 8.2K 1/4W ±5%	3070822	01121
A1R0026	POTENTIOMETER, 1CK	3110349	11237
A1R0027	RESISTOR, 1MΩ 1/4W ±5%	3070105	01121
A1R0028	RESISTOR, 6.8K 1/4W ±5%	3070682	01121
A1R0029	RESISTOR, 100K 1/4W ±5%	3070104	01121
A1R0030	POTENTIOMETER, 10K	3110349	11237
A1R0031	RESISTOR, 110K 1/4W ±1%	3131103	24546
A1R0032	RESISTOR, 33K 1/4W ±5%	3070333	01121
A1R0033	RESISTOR, 150Ω 1/4W ±5%	3070151	01121
A1R0034	POTENTIOMETER, 50K	3110350	11237
A1R0035	TO		
A1R0038	NOT ASSIGNED		
A1R0039	POTENTIOMETER, 10K	3110349	11237
A1R0040	RESISTOR, 931Ω 1/4W ±1%	3139310	24546
A1R0041	RESISTOR, 931Ω 1/4W ±1%	3139310	24546
A1R0042	RESISTOR, 910Ω 1/4W ±5%	3070911	01121
A1R0043	POTENTIOMETER, 10K	3110349	11237
A1R0044	POTENTIOMETER, 10K	3110349	11237
A1R0045	RESISTOR, 931Ω 1/4W ±1%	3139310	24546
A1R0046A,B	RESISTOR, MATCHED PAIR	3129310	01121
A1R0047	POTENTIOMETER, 10K	3110349	11237
A1R0048	POTENTIOMETER, 10K	3110349	11237
A1R0049	RESISTOR, 100Ω 1/4W ±5%	3070101	24546
A1R0050	RESISTOR, 100Ω 1/4W ±5%	3070101	24546
A1R0051	RESISTOR, 432Ω 1/4W ±1%	3134320	24546
A1R0052	NOT ASSIGNED		
A1R0053	RESISTOR, 1.65K 1/4W ±1%	3131651	24546
A1R0054	RESISTOR, 3.3K 1/4W ±5%	3070332	01121
A1R0055	RESISTOR, 100Ω 1/4W ±5%	3070101	01121
A1R0056	RESISTOR, 1.5K 1/4W ±5%	3070152	01121
A1R0057	RESISTOR, 3.01K 1/4W ±1%	3133011	24546
A1R0058	RESISTOR, 1.10K 1/4W ±1%	3131101	24546
A1R0059	RESISTOR, 240Ω 1/4W ±5%	3070241	01121
A1R0060	RESISTOR, 910Ω 1/4W ±5%	3070911	01121
A1R0061	RESISTOR, 6.8K 1/4W ±5%	3070682	01121
A1R0062	RESISTOR, 6.2K 1/4W ±5%	3070622	01121
A1R0063	RESISTOR, 1.2K 1/4W ±5%	3070122	01121
A1R0064	TO		
A1R0067	RESISTOR, 470Ω 1/4W ±5%	3070470	01121
A1R0068	RESISTOR, 100K 1/4W ±5%	3070104	01121
A1R0069	RESISTOR, 100K 1/4W ±5%	3070104	01121
A1R0070	RESISTOR, 10K 1/4W ±5%	3070103	01121
A1R0071	RESISTOR, 470Ω 1/4W ±5%	3070470	01121
A1R0072	RESISTOR, 470Ω 1/4W ±5%	3070470	01121
A1R0073	RESISTOR, 10K 1/4W ±5%	3070103	01121
A1R0074	RESISTOR, 1K 1/4W ±5%	3070102	01121
A1R0075	RESISTOR, 5.1K 1/4W ±5%	3070512	01121
A1R0076	RESISTOR, 150Ω 1/4W ±5%	3070151	01121
A1R0077	RESISTOR, 15Ω 1/4W ±5%	3070150	01121
A1R0078	NOT ASSIGNED		
A1R0079	RESISTOR, 1K 1/4W ±5%	3070102	01121
A1R0080	RESISTOR, 150Ω 1/4W ±5%	3070151	01121
A1R0081	RESISTOR, 1K 1/4W ±5%	3070102	01121
A1R0082	RESISTOR, 150Ω 1/4W ±5%	3070150	01121
A1R0083	RESISTOR, 220Ω 1/2W ±5%	3010221	01121
A1R0084	RESISTOR, 383Ω 1/4W ±1%	3133830	24546
A1R0085	RESISTOR, 402Ω 1/4W ±1%	3134020	24546
A1R0086	RESISTOR, 392Ω 1/4W ±1%	3133920	24546
A1R0087	RESISTOR, 4.22K 1/4W ±1%	3134221	24546
A1R0088	RESISTOR, 4.22K 1/4W ±1%	3134221	24546
A1R0089	RESISTOR, 274Ω 1/4W ±1%	3132740	24546
A1R0090	RESISTOR, 2.21K 1/4W ±1%	3132211	24546
A1R0091	RESISTOR, 10K 1/4W ±1%	3131002	24546
A1R0092	RESISTOR, 3.01K 1/4W ±1%	3133011	24546
A1R0093	POTENTIOMETER, 500Ω	3110346	24546
A1R0094	RESISTOR, 4.53K 1/4W ±1%	3134531	24546
A1R0095	RESISTOR, 4.53K 1/4W ±1%	3134531	24546
A1R0096	POTENTIOMETER, 500Ω	3110346	11237
A1R0097	RESISTOR, 470Ω 1/2W ±5%	3010471	01121
A1R0098	RESISTOR, 576 1/4W ±1%	3135760	24546
A1R0099	RESISTOR, 910Ω 1/4W ±5%	3070911	01121
A1R0100	RESISTOR, 475Ω 1/4W ±1%	3134750	24546
A1R0101	RESISTOR, 475Ω 1/4W ±1%	3134750	24546
A1R0102	RESISTOR, 715Ω 1/4W ±1%	3137150	24546
A1R0103	RESISTOR, 100Ω 1/4W ±5%	3070101	01121
A1R0104	RESISTOR, 5.1K 1/4W ±5%	3070511	01121
A1R0105	RESISTOR, 5.1K 1/4W ±5%	3070511	01121
A1R0106	RESISTOR, 150Ω 1/4W ±5%	3070151	01121
A1R0107	RESISTOR, 10Ω 1/4W ±5%	3070100	01121
A1R0108	RESISTOR, 10Ω 1/4W ±5%	3070100	01121
A1R0109	POTENTIOMETER, 500Ω	3110346	11237
A1R0110	RESISTOR, 1.2K 1/4W ±5%	3070122	01121
A1R0111	RESISTOR, 1.2K 1/4W ±5%	3070122	01121
A1R0112	POTENTIOMETER, 500Ω	3110346	11237
A1R0113	RESISTOR, 174Ω 1/4W ±1%	3131740	24546
A1R0114	POTENTIOMETER, 500Ω	3110346	11237
A1R0115	RESISTOR, 1.2K 1/4W ±5%	3070122	01121
A1R0116	RESISTOR, 1.2K 1/4W ±5%	3070122	01121
A1R0117	POTENTIOMETER, 500Ω	3110346	11237
A1R0118	RESISTOR, 174Ω 1/4W ±1%	3131740	24546
A1R0119	RESISTOR, 174Ω 1/4W ±1%	3131740	24546
A1R0120	RESISTOR, 15Ω 1/4W ±5%	3070150	01121
A1R0121	RESISTOR, 82.5 1/4W ±1%	3130825	24546
A1R0122	RESISTOR, 442 1/4W ±1%	3134420	24546
A1R0123	POTENTIOMETER, 500Ω	3110346	11237
A1R0124	RESISTOR, 100Ω 1/4W ±1%	3131000	24546
A1R0125	RESISTOR, 49.9Ω 1/4W ±1%	3130499	24546
A1R0126	POTENTIOMETER, 2K	3110348	11237
A1R0127	RESISTOR, 7.5K 1/4W ±1%	3137501	24546
A1R0128	RESISTOR, 7.5K 1/4W ±1%	3137501	24546
A1R0129	POTENTIOMETER, 2K	3110348	11237
A1R0130	RESISTOR, 309Ω 1/4W ±1%	3133090	24546
A1R0131	POTENTIOMETER, 2K	3110348	11237
A1R0132	RESISTOR, 9.53K 1/4W ±1%	3139531	24546
A1R0133	RESISTOR, 9.53K 1/4W ±1%	3139531	24546
A1R0134	POTENTIOMETER, 2K	3110348	11237
A1R0135	RESISTOR, 200Ω 1/4W ±1%	3132000	24546
A1R0136	RESISTOR, 19.1K 1/4W ±1%	3131912	24546
A1R0137	RESISTOR, 19.1K 1/4W ±1%	3131912	24546
A1R0138	RESISTOR, 127Ω 1/4W ±1%	3131270	24546
A1R0139	RESISTOR, 1.21K 1/4W ±1%	3131211	24546
A1R0140	RESISTOR, 22Ω 1/4W ±5%	3070220	01121
A1R0141	RESISTOR, 1.21K 1/4W ±1%	3131211	24546
A1R0142	POTENTIOMETER, 10K		
A1R0143	RESISTOR, 33.2K 1/4W ±1%	3133322	24546
A1R0144	RESISTOR, 100Ω 1/4W ±5%	3070101	01121
A1R0145	RESISTOR, 100Ω 1/4W ±5%	3070101	01121
A1R0146	RESISTOR, 4.99K 1/4W ±1%	3134991	24546
A1R0147	RESISTOR, 4.99K 1/4W ±1%	3134991	24546
A1R0148	RESISTOR, 681Ω 1/4W ±1%	3136810	24546
A1R0149	RESISTOR, 330Ω 1/2W ±5%	3010331	01121
A1R0150	RESISTOR, 39Ω 1/4W ±5%	3070390	01121
A1R0151	RESISTOR, 39Ω 1/4W ±5%	3070390	01121
A1R0152	RESISTOR, 2.4K 1/4W ±5%	3070242	01121
A1R0153	RESISTOR, 442Ω 1/4W ±1%	3134420	24546
A1R0154	POTENTIOMETER, 50Ω	3110362	11237
A1R0155	RESISTOR, 49.9Ω 1/4W ±1%	3130499	24546
A1R0156	RESISTOR, 4.7Ω 1/4W ±5%	3070470	01121
A1R0157	RESISTOR, 4.7Ω 1/4W ±5%	3070470	01121
A1R0158	RESISTOR, 3K 1/4W ±5%	3070302	01121
A1R0159	RESISTOR, 15Ω 1/4W ±5%	3070150	01121
A1R0160	NOT ASSIGNED		
A1R0161	RESISTOR, 4.7K 1/4W ±5%	3070472	01121
A1R0162	NOT ASSIGNED		
A1R0163	RESISTOR, 1.5K 1/4W ±5%	3070152	01121
A1R0164	POTENTIOMETER, 1K	3110347	11237
A1R0165	NOT ASSIGNED		
A1R0166	NOT ASSIGNED		
A1R0167	RESISTOR, 1.5K 1/4W ±5%	3070152	01121
A1R0168	POTENTIOMETER, 1K	3110347	11237
A1R0169	RESISTOR, 5.6K 1/4W ±5%	3070562	01121
A1R0170	TO		
A1R0192	NOT ASSIGNED		
A1R0193	RESISTOR, 470Ω 1/4W ±5%	3070471	01121
A1R0194	RESISTOR, 2.7K 1/4W ±5%	3070272	01121
A1R0195	RESISTOR, 47Ω 1/4W ±5%	3070470	01121
A1R0196	RESISTOR, 47Ω 1/4W ±5%	3070470	01121
A1R0197	RESISTOR, 10Ω 1/4W ±5%	3070100	01121
A1R0198	NOT ASSIGNED		
A1R0199	RESISTOR, 47Ω 1/4W ±5%	3070470	01121
A1R0200	RESISTOR, 2.7K 1/4W ±5%	3070272	01121
A1R0201	RESISTOR, 10Ω 1/4W ±5%	3070100	01121
A1R0202	RESISTOR, 47Ω 1/4W ±5%	3070470	01121
A1R0203	RESISTOR, 18Ω 1/4W ±5%	3070180	01121
A1R0204	NOT ASSIGNED		
A1R0205	RESISTOR, 150Ω 1/4W ±1%	3131500	24546
A1R0206	POTENTIOMETER, 100Ω	3110345	11237
A1R0207	RESISTOR, 2.2K 1/4W ±1%	3070221	01121
A1R0208	RESISTOR, 1K 1/4W ±5%	3070102	01121
A1R0209	RESISTOR, 40.2K 1/4W ±1%	3134022	24546
A1R0210	RESISTOR, 40.2K 1/4W ±1%	3134022	24546
A1R0211	RESISTOR, 47Ω 1/4W ±5%	3070470	01121
A1R0212	RESISTOR, 24.9K 1/4W ±1%	3132492	11237
A1R0213	RESISTOR, 1.5K 1/4W ±5%	3070152	01121
A1R0214	RESISTOR, 200K 1/4W ±1%	3132003	11237
A1R0215	POTENTIOMETER, 10K		
A1R0216	RESISTOR, 2.7K 1/4W ±5%	3072702	01121
A1R0217	RESISTOR, 3.01K 1/4W ±1%	3133011	11237
A1R0218	RESISTOR, 2.87K 1/4W ±1%	3132871	11237
A1R0219	RESISTOR, 499Ω 1/4W ±1%	3134990	11237
A1R0220	RESISTOR, 1K 1/4W ±5%	3070102	01121
A1R0221	RESISTOR, 47Ω 1/4W ±5%	3070470	01121
A1R0222	RESISTOR, 51Ω 1/4W ±5%	3070510	01121
A1R0223	RESISTOR, 6.19K 1/4W ±1%	3136191	11237
A1R0224	RESISTOR, 499Ω 1/4W ±1%	3134990	11237
A1R0225	RESISTOR, 51Ω 1/4W ±5%	3070510	01121
A1R0226	RESISTOR, 68Ω 1/4W ±5%	3070680	01121
A1R0227	RESISTOR, 806Ω 1/4W ±1%	3138060	11237
A1R0228	RESISTOR, 10Ω 1/4W ±5%	3070100	01121
A1R0229	RESISTOR, 7.15K 1/4W ±1%	3137151	11237
A1R0230	RESISTOR, 10Ω 1/4W ±5%	3070100	01121

PART	DESCRIPTION	EXACT NO	MFR
A1R0231	RESISTOR, 806Ω 1/4W ±1%	3138060	11237
A1R0232	RESISTOR, 15Ω 1/2W ±5%	3070150	01121
A1R0233	RESISTOR, 27Ω 1/4W ±5%	3070270	01121
A1R0234	NOT ASSIGNED		
A1R0235	RESISTOR, 27Ω 1/4W ±5%	3070270	01121
A1R0236	RESISTOR, 15Ω 1/2W ±5%	3010150	01121
A1R0237	RESISTOR, 4.7Ω 1/4W ±5%	3070047	01125
A1R0238	RESISTOR, 4.7Ω 1/4W ±5%	3070047	01125
A1R0239	RESISTOR, 150Ω 1/2W ±1%	3101500	24546
A1R0240	RESISTOR, 150Ω 1/2W ±1%	3101500	24546
A1R0241	RESISTOR, 150Ω 1/2W ±1%	3101500	24546
A1R0242	RESISTOR, 26.1Ω 1/4W ±1%	3130261	11237
A1R0243	RESISTOR, 26.1Ω 1/4W ±1%	3130261	11237
A1R0244	RESISTOR, 34.8Ω 1/4W ±1%	3130348	11237
A1R0245	RESISTOR, 41.2Ω 1/2W ±1%	3100412	24546
A1R0246	RESISTOR, 41.2Ω 1/2W ±1%	3100412	24546
A1R0247	RESISTOR, 10Ω 1/4W ±1%	3130100	11237
A1R0248	RESISTOR, 46.4Ω 1/2W ±1%	3100464	24546
A1R0249	RESISTOR, 46.4Ω 1/2W ±1%	3100464	24546
A1R0250	RESISTOR, 3.16Ω 1/8W ±1%	3193160	
A1R0251	RESISTOR, 1300 1/4W ±5%	3070131	01121
A1R0252	POTENTIOMETER, 2K	3110348	11237
A1R0253	NOT ASSIGNED		
A1R0254	RESISTOR, 27Ω 1/4W ±5%	3070270	01121
A1R0255	RESISTOR, 2.7K 1/4W ±5%	3070272	01121
A1R0256	RESISTOR, 1.0K 1/4W ±5%	3070102	01121
A1R0257	NOT ASSIGNED		
A1R0258	RESISTOR, 2.4K 1/4W ±5%	3070241	01121
A1R0259	RESISTOR, 2K 1/4W ±1%	3132001	24546
A1R0260	RESISTOR, 221Ω 1/4W ±1%	3132210	24546
A1R0261	RESISTOR, 3.01K 1/4W ±1%	3133011	24546
A1R0262	RESISTOR, 3.01K 1/4W ±1%	3133011	24546
A1R0263	RESISTOR, 3.01K 1/4W ±1%	3133011	24546
A1R0264	RESISTOR, 10K 1/4W ±1%	3131002	24546
A1R0265	RESISTOR, 1.65K 1/4W ±1%	3131651	24546
A1R0266	RESISTOR, 68K 1/4W ±5%	3070683	01121
A1R0267	POTENTIOMETER, 10K	3110349	11237
A1R0268	RESISTOR, 332Ω 1/4W ±1%	3133320	24546
A1R0269	POTENTIOMETER, 2K	3110348	11237
A1R0270	RESISTOR, 4.99K 1/4W ±1%	3134991	24546
A1R0271	RESISTOR, 390Ω 1/4W ±5%	3070391	01121
A1R0272	RESISTOR, 2.7K 1/4W ±5%	3070272	01121
A1R0273	RESISTOR, 1K 1/2W ±5%	3010331	01121
A1R0274	RESISTOR, 100Ω 1/4W ±5%	3070101	01121
A1R0275	RESISTOR, 5.1K 1/4W ±5%	3070512	01121
A1R0276	RESISTOR, 47Ω 1/4W ±5%	3070470	01121
A1R0277	RESISTOR, 10Ω 1/4W ±5%	3070100	01121
A1R0278	RESISTOR, 39Ω 1/4W ±5%	3070390	01121
A1R0279	RESISTOR, 10Ω 1/4W ±5%	3070100	01121
A1R0280	RESISTOR, 5.1K 1/4W ±5%	3070512	01121
A1R0281	RESISTOR, 47Ω 1/4W ±5%	3070470	01121
A1R0282	RESISTOR, 27Ω 1/4W ±5%	3070270	01121
A1R0283	RESISTOR, 27Ω 1/4W ±5%	3070270	01121
A1R0284	RESISTOR, 120Ω 1/4W ±5%	3070121	01121
A1R0285	RESISTOR, 2.2K 1/4W ±5%	3070221	01121
A1R0286	RESISTOR, 10K 1/4W ±1%	3131002	24546
A1R0287	RESISTOR, 3.9K 1/4W ±5%	3070392	01121
A1R0288	RESISTOR, 9.76K 1/4W ±1%	3137761	24546
A1R0289	RESISTOR, 24.3K 1/4W ±1%	3132432	24546
A1R0290	POTENTIOMETER, 500Ω	3110346	11237
A1R0291	RESISTOR, 4.99K 1/4W ±1%	3134991	24546
A1R0292	RESISTOR, 4.02K 1/4W ±1%	3134021	24546
A1R0293	NOT ASSIGNED		
A1R0294	RESISTOR, 10K 1/4W ±5%	3070103	01121
A1R0295	RESISTOR, 10Ω 1/4W ±5%	3070100	01121
A1R0296	NOT ASSIGNED		
A1R0297	RESISTOR, 47Ω 1/4W ±5%	3070470	01121
A1R0298	RESISTOR, 47Ω 1/4W ±5%	3070470	01121
A1R0299	RESISTOR, 249Ω 1/4W ±1%	3132490	24546
A1U0001	INTEGRATED CIRCUIT MC1723CL	1580042	04713
A1U0002	TO		
A1U0005	INTEGRATED CIRCUIT LM741N	1580010	12040
A1U0006	TO		
A1U0007	INTEGRATED CIRCUIT CA3140S	1583140	
A1U0008	INTEGRATED CIRCUIT CA3018	1580029	02735
A1U0009	INTEGRATED CIRCUIT SN7402N	1580021	01295
A1U0010	INTEGRATED CIRCUIT LM710N	1580020	12040
A1U0011	INTEGRATED CIRCUIT CA3046	1580043	02735
A1U0012	INTEGRATED CIRCUIT CA3140S	1583140	
A1U0013	INTEGRATED CIRCUIT LM741N	1580010	12040
A1U0014	INTEGRATED CIRCUIT LM741N	1580010	12040
A1U0015	INTEGRATED CIRCUIT MC7805CP	1587805	04713
A1	PCB, MAIN	4420317	10597
A1	HEAT SINK (Q48, 49) LP73A1WCB W/A2	2000110	98978
A1	HEAT SINK (Q47, 50) TVBF-019-025B	2000102	98978
A1	HEAT SINK (Q44, 46) 207AB	2000067	05820
A3	BURST WIDTH OPTION Y		
A3R2001	RESISTOR, 100K 1/4W 5%	3070104	01121
A3R2002	RESISTOR, 1.2K 1/4W 5%	3070122	01121
A3R2003	RESISTOR, 1K 1/4W 5%	3070102	01121
A3R2006	SWITCH, STOP FREQ-BURST WIDTH	2600502	10597

SECTION 6

PARTS OVERLAY AND SCHEMATIC DIAGRAMS

PEAK LEVEL ADJ
ZERO LEVEL
SINE INPUT ADJ
SINE DC ADJ
SINE AMP ADJ
SWEEP BAL ADJ
RAMP DC
NEG SQ ADJ
POS SQ ADJ
POS PULSE ADJ
NEG PULSE ADJ
-12V ADJ
1MHZ ADJ
TRI PEAK ADJ
+SYM ADJ
-SYM ADJ
VCF BAL ADJ
100K ADJ
PA BAL ADJ
PA GAIN ADJ
SYM FREQ ADJ
EXACT 4420274 REV. B



TRANSFORMER			
FUSE	LINE	"A" TO	JOIN
1/2 A SLO-BLO	100	2	1-4
			2-5
	117	3	1-4
			3-6
1/4 A SLO-BLO	200V	5	2-4
	220V	5	3-4
	240V	6	3-4

3. * INDICATES MATCHED PAIR
2. ALL CAPACITOR VALUES ARE IN MICROFARADS
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, ±5%

NOTES: UNLESS OTHERWISE SPECIFIED

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	RELEASE FOR PRODUCTION	3/28/80	

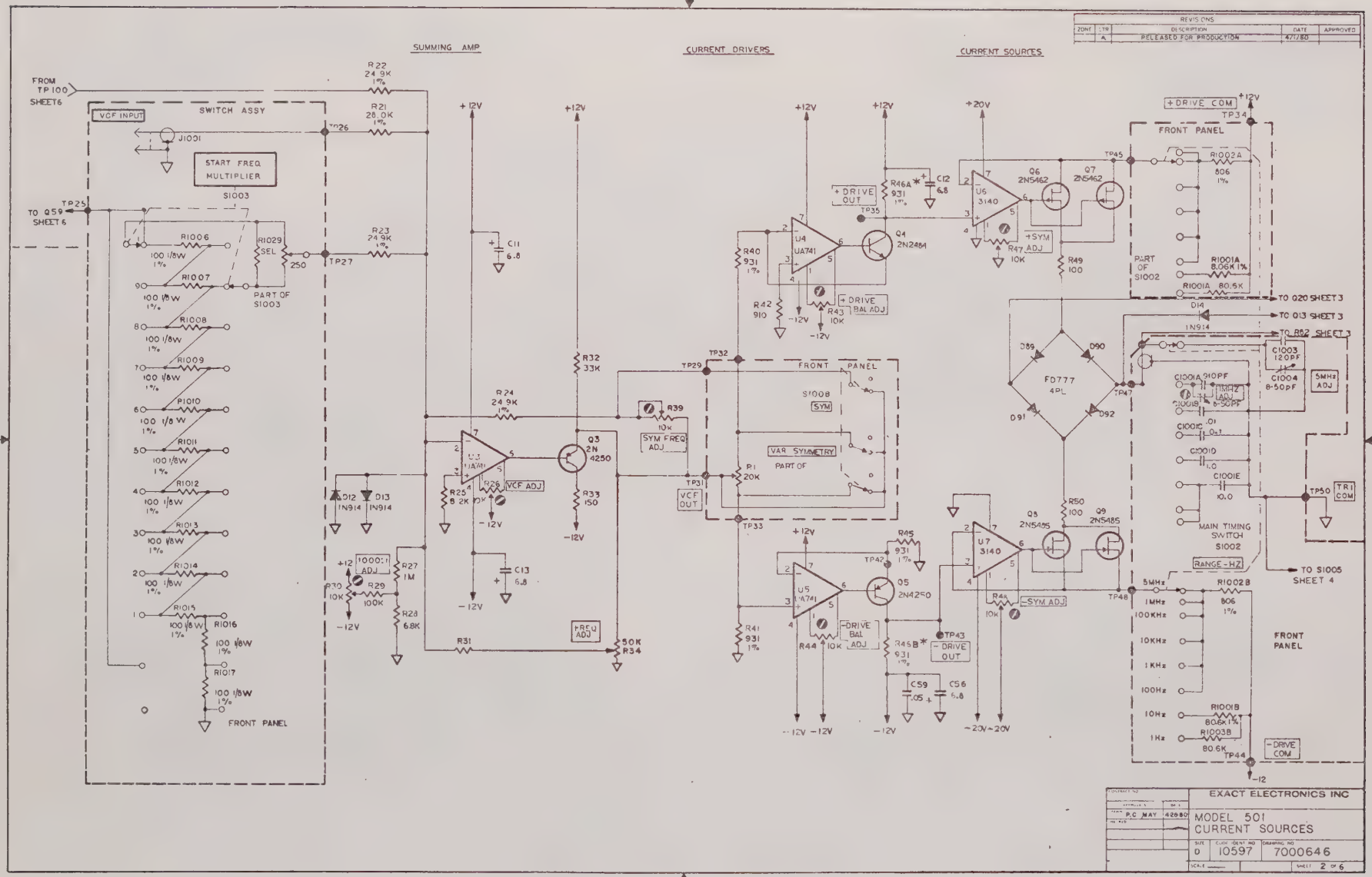
EXACT ELECTRONICS INC.

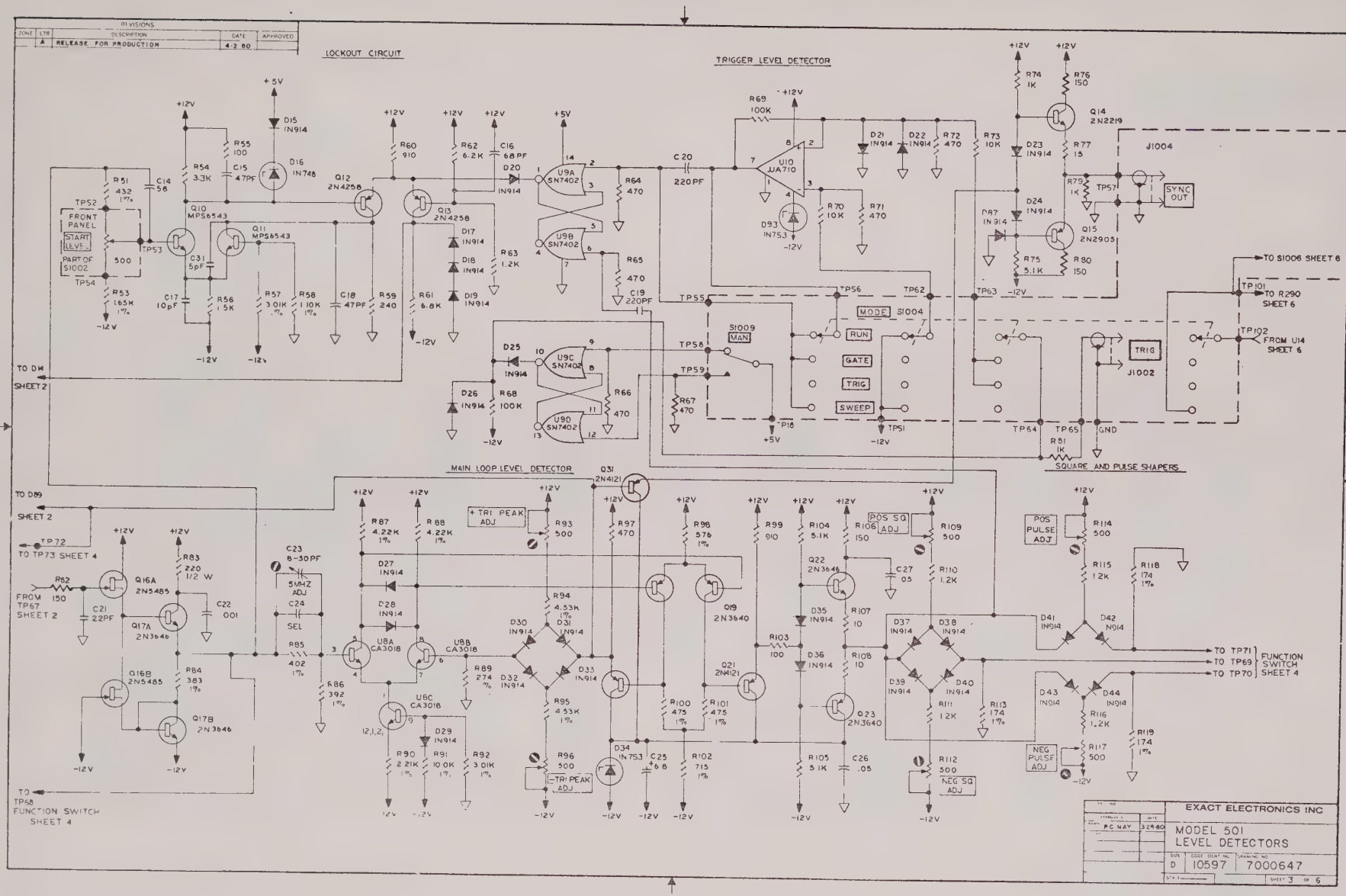
MODEL 501
POWER SUPPLIES

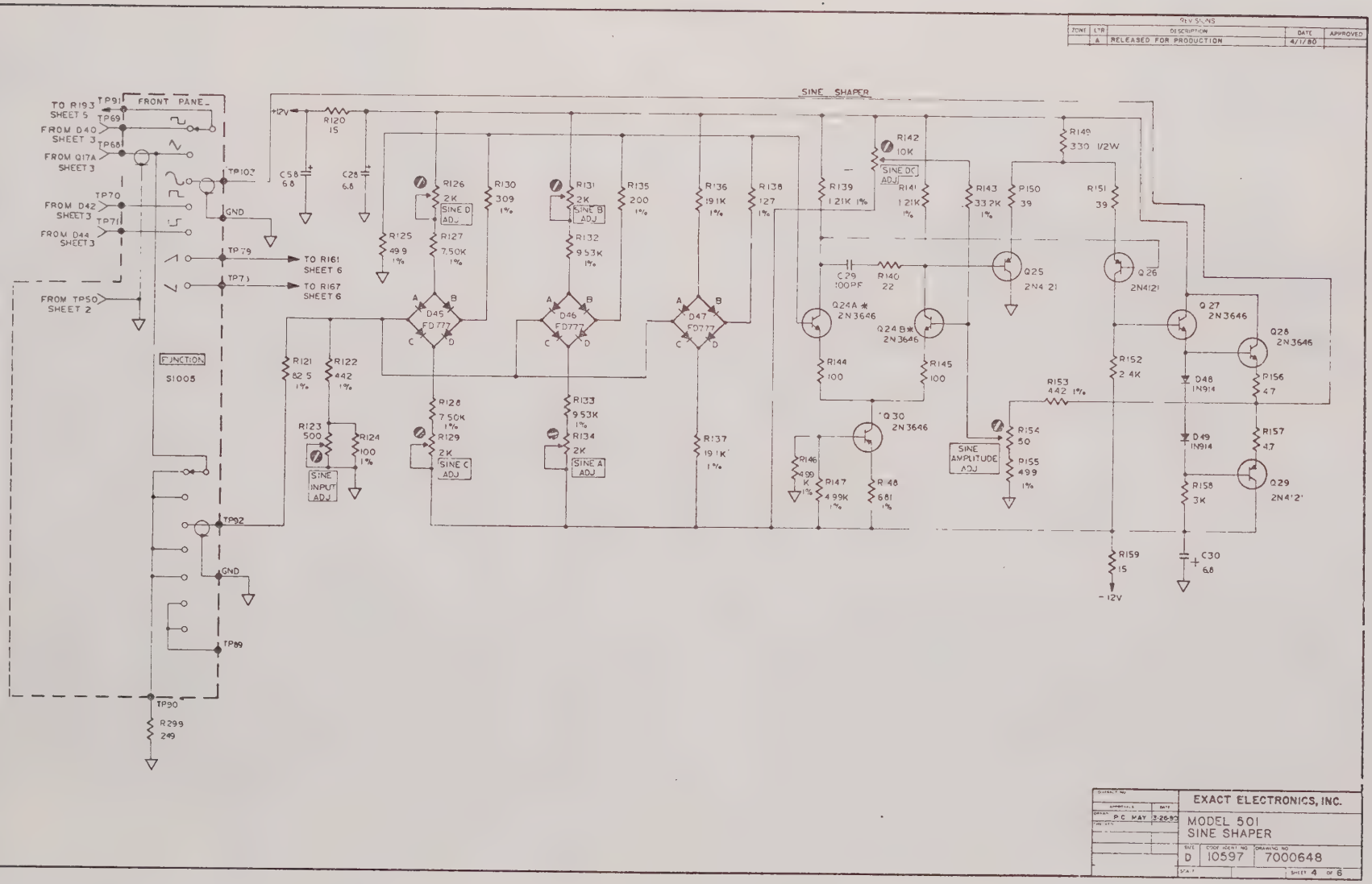
P.C. MAY 3-28-80

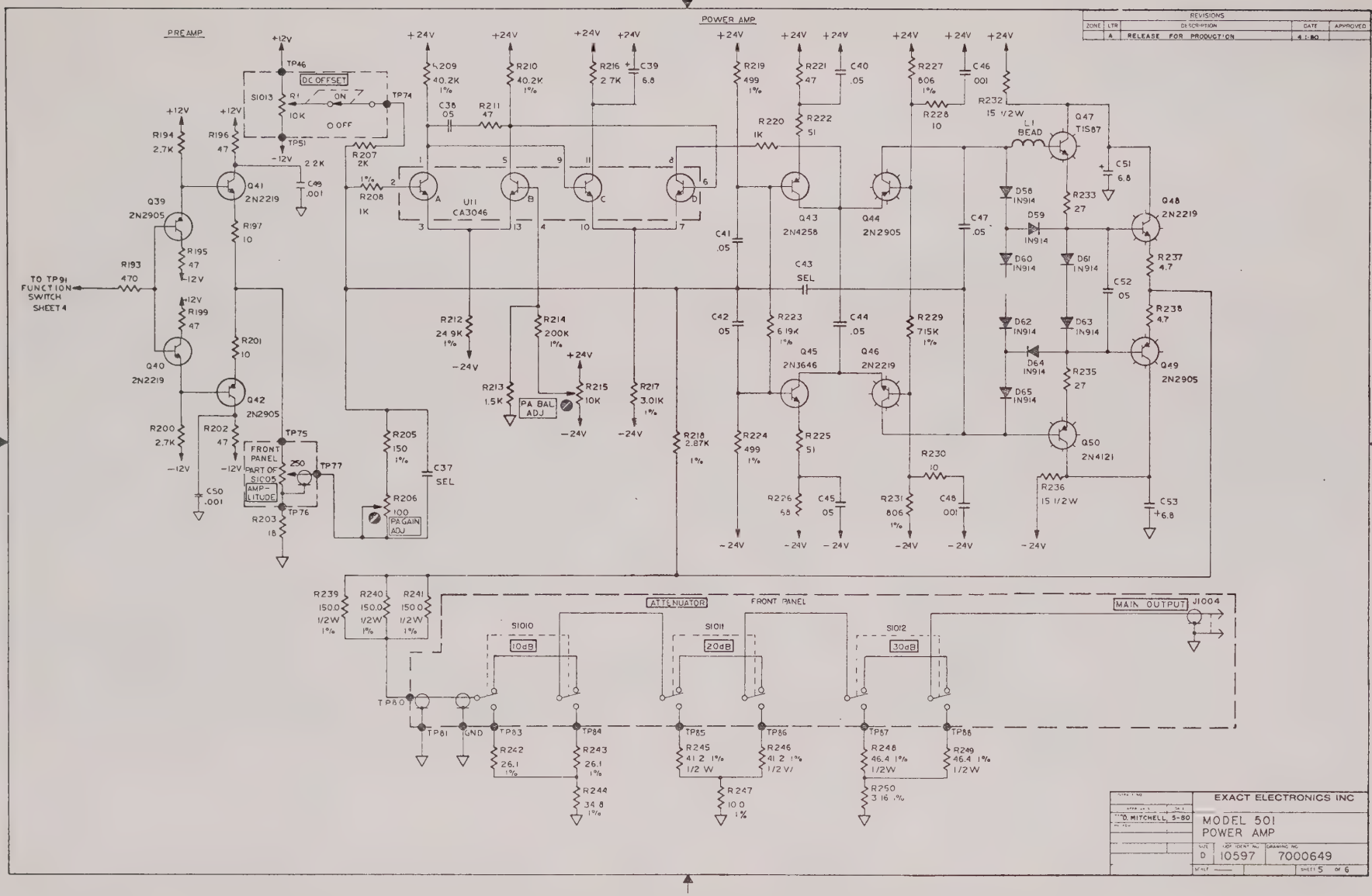
SIZE D | LOOP (DWG) NO. 10597 | DRAWING NO. 7000645

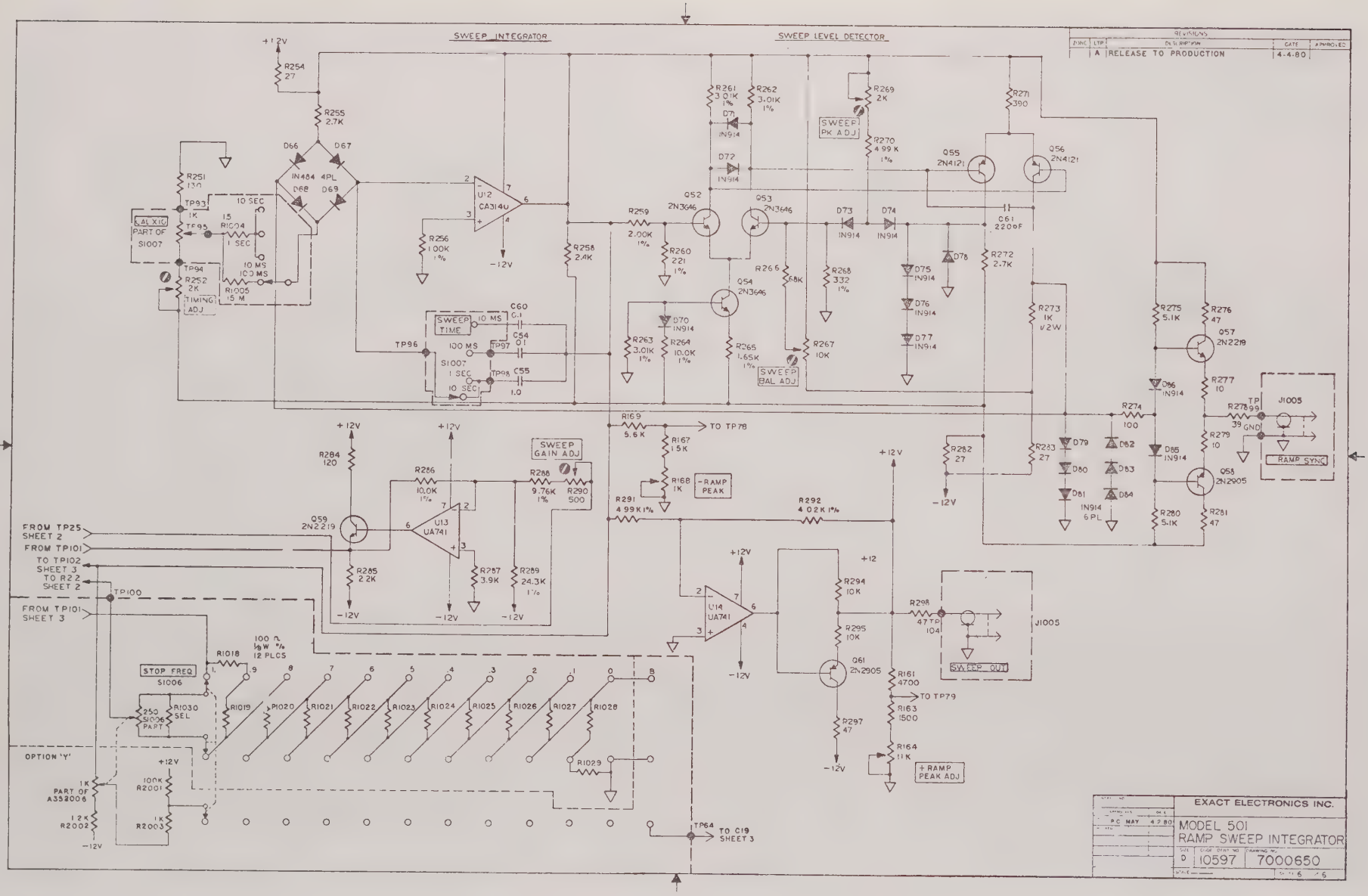
SHEET 1 OF 6


SUMMING AMP
CURRENT DRIVERS
CURRENT SOURCES
REVISIONS
ZONE | LTR | DESCRIPTION | DATE | APPROVED
A | RELEASED FOR PRODUCTION | 4/1/80
FROM TP100 SHEET6
VCF INPUT
SWITCH ASSY
J1001
START FREQ MULTIPLIER
S1003
TP25
TO Q59 SHEET 6
R1006 100 1/8W 1%
R1007 100 1/8W 1%
R1008 100 1/8W 1%
R1009 100 1/8W 1%
R1010 100 1/8W 1%
R1011 100 1/8W 1%
R1012 100 1/8W 1%
R1013 100 1/8W 1%
R1014 100 1/8W 1%
R1015 100 1/8W 1%
R1016 100 1/8W 1%
R1017 100 1/8W 1%
R1029 SEL 250
PART OF S1003
FRONT PANEL
R22 24.9K 1%
R21 28.0K 1%
TP26
R23 24.9K 1%
TP27
+12V
C11 6.8
R24 24.9K 1%
R32 33K
R39 10K SYM FREQ ADJ
U3 1/2 UA741
R25 8.2K
R26 10K VCF ADJ
Q3 2N 4250
R33 150
-12V
D12 IN914
D13 IN914
1000:1 ADJ
R30 10K
R27 1M
R29 100K
R28 6.8K
C13 6.8
R31
FREQ ADJ
50K R34
TP29
TP32
TP31
VCF OUT
TP33
FRONT PANEL
S1008
SYM
VAR SYMMETRY
PART OF
P1 20K
+DRIVE OUT
TP35
R46A* 931 1%
C12 6.8
U4 UA741
Q4 2N2484
R40 931 1%
R42 910
R43 10K +DRIVE BAL ADJ
U5 1/2 UA741
R44 10K -DRIVE BAL ADJ
R41 931 1%
TP42
R45 931 1%
Q5 2N4250
R45B* 931 1%
TP43
-DRIVE OUT
C59 .05
C56 6.8
+20V
-20V
U6 3140
Q6 2N5462
Q7 2N5462
R47 10K +SYM ADJ
R49 100
TP45
+DRIVE COM
TP34
FRONT PANEL
R1002A 806 1%
PART OF S1002
R1001A 8.06K 1%
R1001A 80.6K
TO 020 SHEET 3
TO 013 SHEET 3
TO R62 SHEET 3
D14 1N914
D89
D90
D91
D92
FD777 4PL
TP47
C1003 120PF
C1004 8-50PF
5MHz ADJ
C1001A 910PF
C1001B 1MHZ ADJ 6-50PF
C1001C .01
C1001D 1.0
C1001E 10.0
TP50
TRI COM
MAIN TIMING SWITCH S1002
RANGE-HZ
TO S1005 SHEET 4
U7 3140
Q8 2N5485
Q9 2N5485
R50 100
R48 10K -SYM ADJ
TP48
5MHz
1MHz
100KHz
10KHz
1KHz
100Hz
10Hz
1Hz
R1002B 806 1%
R1001B 806K 1%
R1003B 80.6K
FRONT PANEL
-DRIVE COM
TP44
-12
EXACT ELECTRONICS INC
MODEL 501
CURRENT SOURCES
P.C. MAY 42680
SIZE 0 | CUSTOMER NO 10597 | DRAWING NO 7000646
SCALE
SHEET 2 OF 6


REVISIONS
ZONE | LTR | DESCRIPTION | DATE | APPROVED
A | RELEASE FOR PRODUCTION | 4-2-80
LOCKOUT CIRCUIT
TRIGGER LEVEL DETECTOR
MAIN LOOP LEVEL DETECTOR
SQUARE AND PULSE SHAPERS
FRONT PANEL START LEVEL
PART OF S1002
MODE S1004
RUN
GATE
TRIG
SWEEP
MAN
SYNC OUT
TRIG
TO S1006 SHEET 6
TO R290 SHEET 6
FROM U14 SHEET 6
TO D14 SHEET 2
TO D89 SHEET 2
FROM TP67 SHEET 2
TO TP73 SHEET 4
TO TP58 FUNCTION SWITCH SHEET 4
TO TP71
TO TP69
TO TP70
FUNCTION SWITCH SHEET 4
+ TRI PEAK ADJ
- TRI PEAK ADJ
5MHZ ADJ
SEL
POS SQ ADJ
NEG SQ ADJ
POS PULSE ADJ
NEG PULSE ADJ
EXACT ELECTRONICS INC
MODEL 501
LEVEL DETECTORS
SIZE D | CODE IDENT NO 10597 | DRAWING NO 7000647
SHEET 3 OF 6


REVISIONS
ZONE | LTR | DESCRIPTION | DATE | APPROVED
A | RELEASED FOR PRODUCTION | 4/17/80
SINE SHAPER
TO R193 SHEET 5
FRONT PANEL
TP91
TP69
FROM D40 SHEET 3
TP68
FROM Q17A SHEET 3
TP70
FROM D42 SHEET 3
TP71
FROM D44 SHEET 3
TP79
TO R161 SHEET 6
TP73
TO R167 SHEET 6
FROM TP50 SHEET 2
TP107
GND
+12V
R120 15
C58 6.8
C28 6.8
R125 49.9 1%
R126 2K SINE D ADJ
R127 7.50K 1%
R130 309 1%
R131 2K SINE B ADJ
R132 9.53K 1%
R135 200 1%
R136 19.1K 1%
R137 19.1K 1%
R138 127 1%
R139 1.21K 1%
R142 10K SINE DC ADJ
R141 1.21K 1%
R143 33.2K 1%
R149 330 1/2W
R150 39
R151 39
C29 100PF
R140 22
Q25 2N4121
Q26 2N4121
Q24A * 2N3646
Q24B * 2N3646
R144 100
R145 100
Q30 2N3646
R146 4.99K 1%
R147 4.99K 1%
R148 681 1%
R153 442 1%
R154 50
R155 499 1%
SINE AMPLITUDE ADJ
R152 2.4K
Q27 2N3646
Q28 2N3646
D48 1N914
D49 1N914
R156 4.7
R157 4.7
Q29 2N4121
R158 3K
R159 15
C30 6.8
-12V
FUNCTION S1005
R121 82.5 1%
R122 442 1%
R123 500 SINE INPUT ADJ
R124 100 1%
R128 7.50K 1%
R129 2K SINE C ADJ
R133 9.53K 1%
R134 2K SINE A ADJ
D45 FD777
D46 FD777
D47 FD777
TP92
GND
TP89
TP90
R299 249
EXACT ELECTRONICS, INC.
MODEL 501
SINE SHAPER
P C MAY 3-26-80
SIZE D
CODE IDENT NO 10597
DRAWING NO 7000648
SHEET 4 OF 6


PREAMP
POWER AMP
REVISIONS
ZONE | LTR | DESCRIPTION | DATE | APPROVED
A | RELEASE FOR PRODUCTION | 4-1-80
+12V
+24V
-12V
-24V
TP46
DC OFFSET
S1013
R1
10K
ON
OFF
TP74
TP51
R194 2.7K
R196 47
2.2K
C49 .001
Q41 2N2219
Q39 2N2905
R195 47
R197 10
R193 470
TO TP91 FUNCTION SWITCH SHEET 4
R199 47
Q40 2N2219
R201 10
Q42 2N2905
R200 2.7K
R202 47
C50 .001
FRONT PANEL PART OF S1005 AMPLITUDE
250
TP75
TP77
TP76
R203 18
R205 150 1%
C37 SEL
R206 100 PA GAIN ADJ
R207 2K
R208 1K 1%
U11 CA3046
R209 40.2K 1%
R210 40.2K 1%
R211 47
C38 05
R212 24.9K 1%
R213 1.5K
R214 200K 1%
PA BAL ADJ
R215 10K
R216 2.7K
C39 6.8
R217 3.01K 1%
R218 2.87K 1%
R219 499 1%
R220 1K
R221 47
C40 .05
R222 51
Q43 2N4258
Q44 2N2905
C41 .05
C42 05
R223 6.19K 1%
Q45 2N3646
C43 SEL
C44 .05
R224 499 1%
R225 51
R226 68
C45 05
Q46 2N2219
R227 806 1%
R228 10
C46 001
R230 10
R231 806 1%
C48 001
R232 15 1/2W
L1 BEAD
Q47 TIS87
C51 6.8
D58 IN914
D59 IN914
D60 IN914
D61 IN914
R233 27
Q48 2N2219
R237 4.7
C52 05
D62 IN914
D63 IN914
D64 IN914
D65 IN914
R238 4.7
R235 27
Q49 2N2905
Q50 2N4121
R236 15 1/2W
C53 6.8
C47 .05
R239 150.0 1/2W 1%
R240 150.0 1/2W 1%
R241 150.0 1/2W 1%
ATTENUATOR
FRONT PANEL
MAIN OUTPUT J1004
S1010 10dB
S1011 20dB
S1012 30dB
TP80
TP81
GND
TP83
TP84
TP85
TP86
TP87
TP88
R242 26.1 1%
R243 26.1 1%
R244 34.8 1%
R245 41.2 1% 1/2 W
R246 41.2 1% 1/2 W
R247 10.0 1%
R248 46.4 1% 1/2W
R249 46.4 1% 1/2W
R250 3.16 1%
EXACT ELECTRONICS INC
D. MITCHELL 5-80
MODEL 501
POWER AMP
SIZE D
DOT IDENT NO. 10597
DRAWING NO. 7000649
SCALE —
SHEET 5 OF 6


SWEEP INTEGRATOR
SWEEP LEVEL DETECTOR
REVISIONS
A RELEASE TO PRODUCTION 4-4-80
+12V
R254 27
R255 2.7K
D66 D67 IN484 4PL D68 D69
R251 130
TP93
1K
TP95
15 R1004 1 SEC
10 SEC
10 MS 100 MS
TP94
R252 2K TIMING ADJ
R1005 15 M
CAL XIC PART OF S1007
U12 CA3140
R256 100K 1%
R258 2.4K
-12V
R259 2.00K 1%
R260 221 1%
R261 3.01K 1%
R262 3.01K 1%
D71 IN914
D72 IN914
SWEEP PK ADJ
R269 2K
R270 4.99K 1%
R271 390
Q55 2N4121
Q56 2N4121
Q52 2N3646
Q53 2N3646
Q54 2N3646
R265 68K
R267 10K
R268 332 1%
D73 IN914
D74 IN914
C61 .220uF
D75 IN914
D76 IN914
D77 IN914
D78
R272 2.7K
R273 1K 1/2W
SWEEP TIME
C60 .1
C54 .01
C55 1.0
TP96
TP97
TP98
S1007
1 SEC
10 SEC
10 MS
100 MS
R263 3.01K 1%
R264 10.0K 1%
D70 IN914
SWEEP BAL ADJ
R275 5.1K
R276 47
Q57 2N2219
D86 IN914
R277 10
R278 39
TP GND
J1005
RAMP SYNC
R274 100
D85 IN914
R279 10
Q58 2N2905
R280 5.1K
R281 47
R282 27
R283 27
D79 D80 D81 IN914 6PL
D82 D83 D84
R169 5.6K
TO TP78
R167 15K
R168 1K
-RAMP PEAK
R291 4.99K 1%
R292 4.02K 1%
+12V
-12V
+12
SWEEP GAIN ADJ
R284 120
R286 10.0K 1%
R288 9.76K 1%
R290 500
Q59 2N2219
U13 UA741
R285 2.2K
R287 3.9K
R289 24.3K 1%
U14 UA741
R294 10K
R295 10K
R298 47 TP 104
J1005
SWEEP OUT
Q61 2N2905
R161 4700
TO TP79
R163 1500
R164 1K
+RAMP PEAK ADJ
R297 47
FROM TP25 SHEET 2
FROM TP101
TO TP102 SHEET 3
TO R22 SHEET 2
TP100
FROM TP101 SHEET 3
STOP FREQ S1006
R1018
100 Ω 1/8W 1% 12 PLCS
R1019 R1020 R1021 R1022 R1023 R1024 R1025 R1026 R1027 R1028 R1029
250 S1006 PART
R1030 SEL
OPTION 'Y'
1K PART OF A332006
100K R2001
1K R2003
12K R2002
TP64
TO C19 SHEET 3
EXACT ELECTRONICS INC.
MODEL 501
RAMP SWEEP INTEGRATOR
D 10597 7000650
09

SECTION 7

ADDENDA

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